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ANNOUNCEMENTS.

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Literary Matter to reach the offices not later than the 1st of the month (as much earlier as possible) previous to date of publication. Communications to be addressed "Editorial Department."

Advertisements intended for insertion in next issue must be received not later than the 15th of the month (as much earlier as possible), to insure correct classification. All communications respecting same to be marked "Business Department." Advertising Rates, on application, regulated according to positions available.

Subscriptions and letters with reference to copies to be marked "Subscription Department."

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THE EDITOR will be pleased to consider Literary Contributions dealing with subjects within the purview of this Magazine, and to make satisfactory arrangements with Contributors if MSS. be accepted for publication. High-class engravings from photos and drawings will be prepared free of cost to the writer.

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The War— and the Empire's Trade.

THE whole world is watching with bated breath the appalling struggle now proceeding in South Africa. Not from the unconcerned position of a mere spectator is the conflict being witnessed by the nations, for its issues are invested with the most vital personal interests to them all.

The war, indeed, is one of the direst lessons ever presented to mankind. It represents the overthrow of existing military systems; the introduction to a new era in strategy and tactics, and the consignment of the bulk of current text-books of scientific warfare to the lumber room. Never has the triumph of engineering science over brute force been more signally demonstrated. Against modern weapons, scattering death and destruction with the pitiless accuracy and regularity of a machine, it has been shown that the most heroic personal gallantry may be unavailing. The elimination of the human factor, with its emotional impulses, the waves of reckless enthusiasm, the panic and dismay that in former days decided the issue of the battlefield, has gone far to become accomplished.

In wars of the future, mere animal courage, admirable and inspiring as its manifestations may be, will count for little, in comparison with trained intelligence and the cool and scientific employment of the potent weapons science has now placed at the soldier's command. War, henceforth, will be a combat, not of men, but of machines. From a prime factor, the soldier of the rank-and-file has fallen to the position of an accessory, for his own individual bravery counts for little in comparison with the value of his weapon and the skill exerted in its employment.

The new conditions of warfare, too, will have an important influence on British oversea commerce. The power of defence in modern warfare has been shown to be enormously increased, whilst that of attack has diminished in almost a corresponding ratio. The importance of the British Navy, therefore, has been minimised in one direction and enhanced in another. It appears tolerably sure that a successful invasion of this country in face merely of the land forces at its disposal would be an enterprise of a difficulty almost insuperable. If, therefore, the Navy should no longer possess the critical importance attached to it as a first line of defence, it would, on the other hand, be in a position to employ a larger proportion of its enormous strength in the protection of our merchant shipping from the marauding expeditions which form one of the most disquieting features of a possible European conflict with this nation.

The issue of the war, ending in the triumph of British arms, is assumed by this country with tranquil confidence to be its necessary and inevitable outcome. The checks and reverses which have befallen our troops are accepted as a wholesome, if bitter lesson, which will be learned and profited by to its very dregs. Our soldiers will have passed through the fire to emerge from the furnace like thrice-refined gold; and in the great cataclysm which has so long been impending over Europe, when the bloated armaments of the Continent find their accumulating weight unbearable and are set loose against each other, such experience will stand the British Empire in good stead.

When the war is ended, and South Africa — from Zambezi to the Cape— is submitted to the mild beneficence of British rule, what is to be the commercial position in it of the country which has made such exertions and borne such sacrifices? Is South Africa to become the happy hunting ground of our trade rivals? America and Germany are like hounds straining at the leash, waiting impatiently till we have done the work to pour their capital and their manufactures into the land we shall have thrown open to their enterprises. "Virtue," it has been said, "is its own reward"; it is frequently all it gets; but, speaking for ourselves, we shall not be quite content with so spiritual a satisfaction.

Let us, too, take one concrete case, which will both justify our preceding observations and illustrate our position, which we gather from a communication which has reached us from an anonymous source,

but whose writer invited us to independently verify his statements, which we have done. He is dealing with the Randfontein Gold Mines in the Transvaal (known as the Robinson group), which comprise twelve separate properties, particulars of which he sets out :—

"Some twelve months ago Mr. J. B. Robinson appointed Mr. Hays Hammond, Chief Consulting Engineer to these mines, to make a report on the different properties. The report advised that the stamping capacity of these mines should be increased by the addition in some cases of no less than 100 heads, and that, further, additions be made to the winding, pumping, and air compressing installations. This report was drawn up in conjunction with Mr. John B. Pilchford, the Consulting Mechanical Engineer of the Randfontein Estates Company, and Mr. Pope Yeaman, both Americans, Mr. Hays Hammond being himself a citizen of the United States.

"The expenditure for the total plant is estimated to amount to at least £1,500,000, and no British manufacturers will have the opportunity of bidding for the orders.

"It is perhaps natural that Americans, with comparatively little knowledge of British manufacturers, should give a preference to firms in their own country for machinery they have been in the habit of using. For this reason orders for hundreds of thousands of pounds' worth of machinery have been placed with American firms, which rightly ought to have been placed in this country. I am sufficiently broad-minded to admit that if an article can be procured better and cheaper abroad it would be a mistaken policy to bolster up English industry not to do so; but, in this case, the argument will not hold good. There are firms in England who turn out stamp mills, winding and pumping machinery, air compressors, rock drills, and all plant required at these mines (with possibly the exception of electrical plant) at least equal (in my mind superior) to American make, and certainly at the same or somewhat lower price. Under these circumstances is it right, considering the bulk of the capital invested in the Robinson Mines is English, that Americans should divert the large orders for machinery they control to the United States?

"In *South Africa* of December 2nd last it is stated that all the machinery has been ordered, and will be forwarded to the coast of South Africa ready to be sent to the Randfontein Estates without delay on the cessation of hostilities. This, I understand, on fairly reliable authority, is not the fact. On the other hand, there is no doubt that as soon as the war looks like coming to an end the orders will be placed, and, therefore, no time should be lost in probing the matter to the bottom."

This, though an important, is but an isolated instance of much that will undoubtedly follow the British occupation of conquered territories. The British people of England and the British Colonies are making heavy sacrifices and incurring the gravest risks in their determination to secure for British subjects their legitimate political rights in the South African Continent. For this object, sacrifices are made in a willing spirit; but we think the citizens of the British Empire did not contemplate, as a necessary part of their programme, the clearing of the way at so much cost of blood and treasure for their commercial rivals. The nation, we submit, is entitled to some compensation. The "open door" is assumed to be an essential part of our commercial creed, though we do not think it has ever been officially formulated as such. As a matter of fact, Canada gives some British manufactures preference over those of other nations.

Would it be too much to expect South Africa to do the same?

Ten Years of French Colonial Trade.

It has long been remarked by our foreign rivals that England's colonies are her best customers. The step taken by Canada two years ago in according preferential tariff to the productions of the mother country was noted with a sharp twinge of envy on the Continent. Our competitors there have seen with uneasiness, and even alarm, the relations between Great Britain and her vast dependencies over the world, strong in times of prosperity, grow stronger still at the approach of danger to the parent land. Instead of the process of disintegration they so confidently anticipated, they are confronted with the spectacle of an Imperial British hegemony that is, perhaps, even now, and certainly will be in the future, so powerful that all their united resources must be impotent against it.

The magnificent position which Greater Britain has attained through her Colonies is mainly accountable for the frantic exertions of our rivals to occupy alien territories, which have characterised their national policy during the past ten years. France

especially has been extraordinarily aggressive and enterprising. She has managed to secure the largest, though by no means the richest, share of Africa, her possessions there covering some 3,000,000 square miles—equal to the territory of the United States—and embracing a native population of 27,000,000 now under French dominion. She possesses also Madagascar, and other islands and territories in Indo-China, and in the North, South, Pacific, and Indian Oceans.

The first step of the French Colonial authorities, on the acquirement of a new territory, is to convert it, by the imposition of differential duties, into a preserve for the French exporter, and the effect of this policy, as it affects other industrial nations, is well exemplified in Madagascar, where, although it does not appear that French exports materially increased, those of Britain to that island were reduced in one year (1897-1898) from £158,610 to £34,604. That this policy is the dominating one in French annexation, and that it will continue to remain so, there can be no doubt. Vast areas of the world are henceforward to be shut out from other than French trade and commerce. Bearing this in mind, it may be useful for us to enter into a short examination of French Colonial trade as presented in various Reports made upon it on French authority, and embodied by Mr. Austin Lee in a Consular Report recently issued.

During the past ten years, it appears, the national expenditure on French Colonies, as represented by the "Colonial Budget," has been altogether £32,883,263, or about an average of £3,200,000 a year. This expenditure is almost wholly unconcerned with development work, but is consumed for the most part by the multitude of officials which it appears to be the chief mission of French colonies to support. The exports from France to her colonies, on the other hand, amount only to an average of £4,250,000, while it costs her £3,200,000 to maintain these colonies as a market. A Report on the 1896 Budget for the Chamber of Deputies emphasises this fact: to quote verbatim, "A market worth 95,000,000 francs costs us 80,000,000 francs a year." It will be seen, therefore, that the economic situation of the colonies of France is a constant drain upon the national purse, and that as this outlay is almost wholly absorbed by administrative charges, it is unproductive, as being without a prospect of bearing any return. In other words, a sheer loss.

To the unprejudiced observer, in this violent colonial expansion so strikingly manifested by our neighbours, they would appear to have left out of mind one primary essential of a successful colony, viz., the possession of colonists wherewith to colonise them. Throughout the whole tale of French foreign possessions the complaint is uniform; stagnation and decay through want of immigration. True it is that a large proportion of French oversea possessions are climatically unfitted for permanent European settlement. But France holds colonies whose climate and natural resources are in every way adapted to her home population. In New Caledonia, for instance, the land is fertile, and rich in the most valuable mineral deposits. Yet, though the island was acquired by the French nearly fifty years ago, its means of interior communication are still for the most part in the same primitive condition in which they were found, and the copper, cobalt, and nickel mines are being worked by five English companies. France is a sterile nation, and, with a declining population, can only hope to colonise in the sense that Spain colonised Mexico and Peru. They may exhaust the riches of other soils for the benefit of their own, but the hope our neighbours seem to possess of building up a colonial trade with a "Greater France," in the sense of a "Greater Britain," will never be realised.

British Consular Trade Reports.

SHOULD THEY BE PUBLISHED?

THE Commercial Department to the Board of Trade has become an actuality, and entered on an active career which has already covered some four months. Although there are few outward and visible

signs of its existence, it probably prefers, like some philanthropists of the extreme type, to do its good work in the dark. To its agency, in any case, must be ascribed the circumstance, that we are now privileged with the publication of the *Board of Trade Journal*, four times, instead of once a month, and at a price which brings it within the slenderest resources of the general public. True, we have not been able to discern in the hebdomadal development of this organ, any great change—may we say improvement?—in the nature of its contents; the chief noticeable new features being a remarkable decline in the number of its advertisements, and an obvious reliance for a considerable proportion of its literary matter on the press-cutting agencies. However, the British public have been taught to expect little from a Government Department, and, taking it all in all, from a publisher's point of view at least, the *Board of Trade Journal* is not a bad pennyworth.

There is one point, however, in connection with the *Board of Trade Journal*, on which we own to being a little puzzled. In several numbers recently we have noticed certain "tips" to British manufacturers as to orders they might possibly obtain by application to sources indicated. Now, we understood that the Commercial Department proposed to make a charge for information of this kind. Are the "tips" we refer to then, intended to encourage regular paying applicants by showing them the nature of the information at the Commercial Department's disposal, or are they put in simply with a conscientious desire to give the public a generous pennyworth? We are fully aware that assumptions of this sort are not quite in accordance with the dignity of a State Department. That may be. But, on the other hand, is it not rather undignified in a State Department to tout for advertisements in competition with publications established and conducted by private persons and with private capital? We all know that the official revenue of the Commercial Intelligence Department is sufficiently modest to incite the exercise of every means for the augmentation of its income; we certainly do not suppose that it will ever be reduced to the level of the Imperial Institute and solicit enquirers to remit in advance the money for the postages entailed by their applications; but, bearing the possibility, however remote, of this contingency, in mind, any steps almost might be deemed legitimate to avert such a humiliation. A vigorous canvass for advertisements, with reduced terms in special cases, made throughout this country might restore the depleted advertisement section of the *Board of Trade Journal* to its former corpulency and greatly facilitate the transaction of the important public duties the department has in charge. Failing this, a judicious appeal to the patriotism and public spirit of the British manufacturers in general, might be accompanied with beneficial results. Wishing our Government contemporary every success in this direction, we turn to an aspect of the Official Trade Reports which has been presented to us from various quarters, and has not been touched upon by us up to the present time; it is well expressed in the following communication, which has been received by us from the offices of a distant, but very important, Consulate situated on the other side of the world:

> "Your articles on consular reports are very interesting, as it is rare to find intelligent criticism of a part of our work, which I do not hesitate to say is, as far as the consuls are concerned, conscientiously performed. But we are not able to travel about our districts, and at a busy port like this are fully occupied with our duties with British shipping and seamen.
>
> "Hence, such reports should be entrusted to commercial attachés or commercial vice-consuls. But it is my firm opinion that we should best benefit British trade by giving all publicity to the consular reports of other nations, while communicating British consular reports privately to British chambers of commerce and to British chambers of commerce alone.
>
> "It is worthy of note that the valuable trade reports of German consuls are never published for the benefit of foreign nations.
>
> "British consular reports are much more valued in foreign countries than they are in the British Empire, and have done much to point out to foreign competitors fresh openings for trade at the expense of British traders.
>
> "With all submission to your valued criticism, it is not so much the shortcomings of British consular reports, but the injudicious publication of these reports which call for immediate remedy."

Our consideration of the Consular Reports, as they apply to trade and commerce, has hitherto been exclusively confined to the method of their preparation and the means employed to bring them before the attention of those interested in them. We have not touched on the question raised by our correspondent, but we think few will disagree with his opinions on the subject. The carrying out of his recommendations would, of course, entail the deletion of all commercial information of immediate interest from the Consular Reports, and its private dissemination through such an organisation as the Commercial Intelligence Department of the Board of Trade, which, indeed, has been established for that express object. One question remains. Considering the ability, the zeal, the suitability of the staff of this Department for their duties, is the financial aid afforded to it by the Treasury adequate to their proper carrying out? We may have a word or two to say on this matter in a forthcoming issue.

Last Year's Results of Physical Research.

THERE have been no very startling discoveries in physical science during the last year, nor are there to be registered any epoch-making inventions among its applications; but considerable development has taken place, nevertheless, in theory as well as in practice, and steps have been attained in the direction of progress which deserve to be recorded. As regards theoretical research a very remarkable hypothesis has been brought forward by Professor J. J. Thomson, which, if it should be found to fit all empirically ascertained facts to which it can be applied, would render the atom a variable quantity instead of an invariable one, such as hitherto it was assumed to be, and, in fact, render its name inappropriate. Professor Thomson, in his noteworthy researches on the action of the X-rays on gases, was induced to assume the existence of masses smaller than what has up to now been called the atom. He found and verified in various ways that the ratio of the mass of the atom to the electrical charge carried by it is but about one-thousandth of that calculated by other experimenters on the basis of the current hypothesis on the size of atoms. He thereby was led to inquire whether the atom conveyed an electric charge as a whole or whether the charge is carried by one portion of the atom only; in other words, whether what was assumed to be an atom consists of two portions, a smaller fraction and a large remainder, of which the former is negatively charged while the bulk carries a positive charge. His experiments led him to the conviction that such is really the case, and he also thinks he has found confirmation of this in the evidence of the spectroscope. This hypothesis is, at all events, worthy of careful study, and, if tenable, would necessitate a complete revision of the atomic theory.

Since it was during research on the action of the X-rays that this interesting conclusion was reached, we are naturally led to enquire what progress has been made in the study of the phenomena discovered by Prof. Röntgen. The theory that these rays are due to very short light waves has not yet been conclusively established. Messrs. M. Maier, H. Haga, C. H. Wind, and others, believe that the wave of the X-rays is less than one-millionth of an inch, which is a very great difference from that of the luminous waves of the solar spectrum, which are as long as one-fifty-thousandth of an inch. As regards the practical application of Prof. Röntgen's discovery, it may be said that at present there are few hospitals that are not equipped with an X-ray apparatus, which enables surgeons to locate foreign bodies, and physicians to study the progress of disease in the lungs, and to observe the movements of the heart, while the dental surgeon also has obtained through it a convenient means for studying the condition of the teeth and jaw from the shadows, thrown on sensitive films placed in the mouth, by the rays of a Crookes' tube situated outside. Great though the benefits are that have been obtained by radiography, as is the case with all new discoveries, the application

has caused in some instances injuries, and is connected with dangers, the cause of which will have to be carefully studied. In some cases, by the exposure of the skin to X-rays, severe burns have been caused, resembling sunburn. The effect, however, is far more serious, as it reaches deep down, apparently affecting the organs of nutrition of the tissues, and being progressive in its nature.

A very important recent discovery is that there are various substances, such as salts of uranium and certain compounds of pitch-blende, that give off X-rays. They have been termed radio-active substances, and if some of these in a powdered form are strewed on cardboard, rays emanate that traverse opaque bodies, throw shadows of the bones of the hand on photographic plates, render luminous fluorescent screens, dissipate electric charges, &c.; in fact, act exactly like the rays obtained from Crookes' tubes. This discovery may lead to very important practical results, and perhaps will make it possible to dispense, in future, with the complicated X-ray apparatus, and to use but the powdered radio-actives in surgical investigations.

The same electric energy that causes the infinitesimally short X-rays to emanate from a tube in which a partial vacuum has been obtained produces the waves, from 3 to 4 ft. long, that have recently been employed with success to send telegraphic messages to distant places without the aid of wires.

As in the case of many applications of physical discoveries, here also the name of the successful experimenter, who first obtained practical results, has become connected in the popular mind with the invention itself, and the name of Marconi is now-a-days identified with wireless telegraphy. Before the eyes of the student of science, however, there rise in succession the discoveries that gradually led to the practical results now obtained, and one is forced to return at least as far as the discovery which induced Lord Kelvin (then Sir William Thompson) to form his theory regarding electric oscillations, to the later modification of this theory by Clerk Maxwell, leading to the electro-magnetic theory of light, and the various results of the great discovery by Hertz how to produce and to detect electric radiation with waves much longer than can affect the eye. Then follow the experiments of Brauly in France, who invented a sensitive detector by means of which electric radiation emitted from a Hertz vibrator can be detected at a distance of many yards, the researches by Righi in Italy, by Bose in Calcutta, and by Pysoff in Russia, until finally we reach Marconi, who has succeeded in sending messages great distances over sea, as Professor Saby has succeeded in sending them over somewhat shorter distances overland, and M. Ducretet, who has constructed an apparatus for the same purpose that has been used with great success in France. Thus, the so-called Hertzian waves have finally been rendered serviceable to man's practical needs, but much will yet have to be done in research and experimentation ere many of the hopes based on, what is called, wireless telegraphy can be fulfilled. Thus, for obviating collisions of vessels during fogs, it does not suffice that a course on which a vessel is sailing be communicated, as can be done by Marconi's system, but it will be necessary that the bearing of the vessel is known, which will be the case only when it is possible to send a message in a definite direction without its affecting receivers in any other line of the area which the waves traverse. There is also required an apparatus rendering it possible to increase the frequency of the interruptions of the electrical current, which are at present the means employed for sending telegraphic messages without wires. The Wehnelt interrupter, one of the most noteworthy inventions of last year, answers this purpose on the whole remarkably well; it is, however, very short-lived, and requires a great amount of energy for starting it. Many improvements have been suggested, but none, so far, is entirely satisfactory.

Next to the development of wireless telegraphy, the successful production of liquid air on a large scale counts among last year's achievements; and by a kind of fractional distillation of liquid air Prof.

Ramsay has discovered two new gases—Neon and Metargon.

A new metal has also been added last year to the list of those hitherto known by Prof. Crookes, who called it Victorium. The discovery was due to experiments in spectral analysis, and it was obtained from the rare earth Yttria. Spectral analysis has also continued to occupy the attention of Rubens, who in his investigations of the red end of the solar spectrum by repeated reflections of heat waves from surfaces of quartz and mineral sylvine has succeeded in isolating very long waves of heat. These investigations of the red end of the spectrum, which are carried on among others also by Prof. Langley, who has succeeded in constructing remarkably sensitive measuring instruments, will, no doubt, ultimately lead to the practical realisation of colour-photography. The ordinary dry plate is sensitive enough to the blue and violet rays, and now plates can be manufactured that reproduce the red, yellow and green of the spectrum. A further result of spectroscopical experiments is the invention of a new spectroscope by Professor Michelson, serving admirably for the minute study of portions of the spectrum, and by its means lines that in the ordinary spectroscope seem single have been dissolved into widely separate lines.

The use of aluminium as a substitute for copper has already been alluded to in these pages, and the results so far obtained indicate that there are great prospects for its extensive employment as an electrical conductor. This brings us to the developments of electrical applications. The distance over which high voltages of current are being transmitted has been steadily increasing; and one recent plant in the United States will convey current at 60,000 volts over conductors having a length of 155 miles—the greatest distance so far reached. The notable feature of the year has been the development in the employment of alternating current, which alone renders such long transmissions possible. Formerly "unaccounted for current," as Mr. Henry L. Doherty remarked in a recent lecture, in alternating stations often amounted to 80 per cent. of the output, while 60 per cent was more nearly the average than the extreme. Modern transformers, however, and modern methods promise to reduce this "unaccounted for current" to an insignificant amount.

The above have not been the only achievements in the field of physical science during last year, but, perhaps, some of the most important, and limits of space, at all events, prohibit us from adding to a list which, even as it stands, shows that there has been no standstill in physical research and practical employment of its results.

The Coal Market.

In every part of the kingdom, coal owners, dealers, and miners give indications that they are well pleased with themselves and each other. Disputes and strikes are put aside, and the three classes live together as a happy family, serene in the consciousness that the manufacturer and the householder must pay any further demands which may be preferred in reason or out of reason. The Miners' Federation is in an especially good humour, and looks with the utmost complacency upon the share which it has obtained in the prosperity of trade done by other people. Mr. Pickard, the president, has recently delivered an address to members, setting forth in glowing language the intrinsic merits of the settlement at present in force, and rejoicing over the conversion of the Welsh miners from heretical belief in the sliding scale This gentleman looks forward to a further rise in the price of coals, and a consequent addition to the incomes of the miners. Coal owners are everywhere putting up prices to dealers and consumers; dealers in turn are raising prices to the public, and there are rumours that extensive amalgamations have been formed with the object of stifling competition. Gratifying as all these circumstances may be to those within the inner circle of coal operations, very little satisfaction is expressed by the classes who have to pay unjustifiable prices, and all who have the

true welfare of the country at heart must look with regret at the determined attack which is being foolishly and selfishly made upon the commercial prosperity at present existing. Several blast furnaces in Scotland have already been damped down for want of fuel, and difficulties have occurred at other ironworks, which will probably lead to curtailment of production. Many industrial concerns are severely affected in a greater or less degree, and when it is remembered that the industrial position is one involving not so much high prices as a large turnover at small profits, it will be seen how serious a matter every rise in the cost of coal becomes to the manufacturer. It does not appear that there is any scarcity of the material itself to account for the insufficiency of supply, which is to some extent due to reduced production, and partly to difficulties of transport. From the North of England a report comes that the collieries are producing less coal than usual, and that as a result of the calling-up of the Reserves and of the Militia fewer men are at work, whilst those who are actually working are in every case earning wages on a higher scale than usual and are content to put in less time. In some parts of the Midland counties measures have been taken with the object of increasing the output. A colliery near Birmingham closed by reason of fire in 1898 has been re-opened, new shafts are being sunk at Sandwell Park colliery, in Staffordshire, some mines at present closed will shortly be worked, and at least four new pits in Warwickshire will be opened. With respect to the question of transport it is stated by the railway companies that traffic has never been so heavy as at present. Not only are more wagons and trucks said to be wanted but also more locomotives!

Generally, it must be remarked that the position is highly unsatisfactory to the community at large, and although a certain increase of market price would be only natural and proper, it is not easy to find justification for the excessive demands made by those concerned in the production and sale of coal. One very undesirable feature is the general principle of the arrangement between masters and men, in virtue of which prices are not permitted to fall below a certain standard. The creation of artificial prices simply for the benefit of capital and labour constitutes a flagrant injustice to the rest of the community, and hardly serves to strengthen the hands of the manufacturer in resisting the ever-increasing pressure of foreign competitors.

Water Meters.

One of our contemporaries has recently discovered that "the besetting sin of London is its dirtiness." This revelation appears to have been due to recent manifestations of more or less arctic weather with which we have lately been favoured; but the accusation is levelled more particularly against London, regarded rather as an abstract and soulless thing than as a collection of human beings having knowledge of good and evil. There is a general impression, possibly not without some foundation of fact, that London, considered in the last-named sense, is not entirely without its share of moral obliquity, in which wastefulness might not unreasonably be said to occupy a prominent position. Putting aside controversial matters of municipal expenditure, we find ample evidence of thriftlessness on the part of Londoners themselves, and in no direction is this attribute more inexcusable than with regard to the waste of water. It is an admitted fact that no less than ten gallons per head of the London water supply is wasted daily. Taking the population at five millions, this quantity represents a total waste of 50,000,000 gallons per day, or enough to supply 25 gallons per head per day to an increased population of two millions. In other words, the water deliberately thrown away by Londoners would be sufficient for the needs of the city of Berlin, and if this state of things is permitted to continue, a capital expenditure of £8,000,000 will be required in order to make good the deficiency resulting from preventible waste. Here, then, is a great problem, the solution of which, we believe, is only to be

attained by concerted action, having for its object an entire alteration of the terms upon which water is supplied to the public. At present the water companies are doing everything in their power to minimise losses, but their jurisdiction is confined within narrow limits, and it is very unlikely that consumers will try to economise so long as payment is regulated by empirical assessments.

In the present unregenerate condition of the human race it is probable that the only feasible solution of the problem is the establishment of a definite ratio between purchase and payment, such as obtains in the case of all other commodities. Before this can be done the alteration of existing enactments must be undertaken by Parliament, and it is also very desirable that a type of water-meter should be produced which would be acceptable both to the water companies and to the public. Amongst the various forms of meters now on the market none seem to be altogether approved by water engineers, though several of them are largely used with satisfactory results. Of course, any meter employed in connection with the supply of water should be of such a type that pressure from the main is not reduced, otherwise it would be necessary for the apparatus to be fixed at the top of the premises, which, for many reasons, would be a most inconvenient position, besides depriving the company of proper facilities for the examination of service pipes. Meters ought to accurately measure all water passing through them, whether the flow be great or small; they should not be liable to get out of order, the wearing of working parts should not interfere with registration, whilst compactness, adaptability, and reasonable lowness of first cost are other essential characteristics. Unfortunately some kinds of meter, when deranged, have a tendency to cut off supplies, a contingency which consumers are never likely to approve; and other types, again, are extremely likely to allow the passage of water without registration, a quality not at all popular in the estimation of the water companies. These two opposing features cannot be reconciled, and the only *modus vivendi* would be the invention of a meter which, for all practical purposes, cannot get out of order. Most reliable appliances of the kind now manufactured come under one of two main types—Inferential and Positive meters. In the former class, water is not actually measured, but is calculated from the number of revolutions of a fan or turbine actuated by the flow. The worst faults alleged against inferential meters are that dribbling flows are not of sufficient force to actuate the fan although water still finds its way to the consumer, and that the moving parts are sometimes clogged, or set fast, owing to the accumulation of deposited matter. Positive meters are constructed on entirely different lines, and they all have one or more internal spaces which are alternately filled and emptied by the water furnished. As the exact capacity of each space is known, there can be no possible mistake as to the volume of water passing within any given period. The most approved forms of positive meters are those in which cylinders, fitted with pistons and controlling valves, constitute the measuring spaces. Some varieties are bulky as to dimensions, and noisy during operation; others are insufficiently provided with contrivances for rendering them water-tight at various pressures, and under diverse conditions of service; and others are apt to require frequent repairs, and to set fast when used for measuring water containing suspended particles. One of the most ingenious meters which we have seen is one recently described at a meeting of the Institution of Mechanical Engineers. This machine has three cylinders, through which the flow of water is practically uniform, as in a three-throw pump, there are few working parts, and by removal of the cover the whole apparatus can be inspected, cleaned or repaired. Several well-known waterworks' engineers speak well of the apparatus, and it is certainly a move in the right direction. In view of the advantages to be derived from the supply of water by measure, we commend to manufacturers of meters the policy of endeavouring to produce such an appliance as will induce the water companies to favour the adoption of a much-needed reform.

"We are, in the vastness of our possessions, losing our grip on national sentiment. It is our duty to maintain intact, and to defend by sea and land, all that our empire builders have left us. The day that sees the defence of the British Empire sapped, sees the disintegration of the Nation's trade and the hands of civilization's timepiece put back 200 years."—RT. HON. LORD CHARLES BERESFORD, C.B.

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Armour-Plate *v.* Projectile . . .

EVER since Ericsson launched the first "monitor," a kind of duel has been going on between armour-plate and projectile, in which each has scored about an equal number of points. The first kind of armour-plate to be made was composed of wrought iron, which withstood the impact of the current projectile fairly well. The Armstrong gun, however, and Palliser shot made very short work of it, and wrought-iron plates were soon found to be useless in face of the improved means of attack made against them.

Though we experimented with steel long ago, the credit of first producing effective steel armour rests with the French, whose mild steel facings were superior to the compound plates—that is, hard steel with wrought-iron backing—used in the British navy.

The next advance, and a very important one, came from the United States, and at the time of its introduction into this country it created a considerable sensation. An American, one Harvey, perfected and made commercially practicable, a means of giving mild steel armour-plate an intensely hard surface by a process of "Cementation"; otherwise imparting to its surface a considerable proportion of carbon by prolonged heating in a charcoal furnace, whilst the rear retained its original ductile and tough condition. Against such a plate, the existing service projectile split up into fragments.

Still again, higher muzzle velocities and modifications in the form and composition of the projectile rendered the victory of the "Harveyised" plate by no means so certain or complete as was anticipated. An improvement on the "Harvey" process was soon after inaugurated by the well-known firm of Krupp, and this, up till now, has proved in every way so superior that its use has been rendered compulsory with not only the British but the United States Government. Krupp's improvement comprises two points—the composition of the metal, and the method of its treatment. As regards the first, the firm have been successful in obtaining a material of very tough nature, yet possessing great tensile strength, with a high elastic limit. Also by carburising the surface by gas cementation instead of charcoal, much more regular and satisfactory results are obtained; and up to the present, Krupp armour has been considered, though not an absolutely complete, yet a fairly satisfactory solution of the problem.

It is understood, however, that the projectile, though temporarily defeated, is by no means disposed of. The smashing of the projectile against the hard but tough skin of the modern armour-plate has been obviated to some extent by the employment of a soft metal cap on its point, the missile burying itself in the plate instead of devoting its striking energy to its own destruction. Sir R. A. Hadfield, the well-known ironmaster and metallurgist, announces that his firm have been successful in producing a capped projectile, which, with a slightly higher velocity than the present average, readily perforates hard-faced plates; and he adds his conviction that before long the latest

type of armour-plate will be found quite vulnerable.

Considering the enormous cost of armour-plating, such a prospect is certainly most disquieting. Sir Robert Hadfield's experiments are of no recent date. For years he has been engaged in trials and tests of projectiles and armour-plates of the most elaborate and exhaustive description. His judgment on a matter that so deeply affects our national interests is one of authority, and entitled to all the respect that can possibly be accorded to it.

Municipal Disposal of Street Refuse . . .

In our editorial note on this subject in our last issue, we referred to the paper read by Mr. Russell before the Institution of Civil Engineers, but had not space to deal with the discussion which followed. The paper, of course, called public attention to the question of the disposal of refuse and its utilisation, but only gave the results of one system of disposal and utilisation. In the olden days there was considerable discussion whether it was not cheaper to get rid of the dust by barges, especially where a district lay contiguous to a river, or by any other means of carriage to a waste place, rather than by destroying it by fire in a destructor. On one occasion we remember a great accumulation of dust took place in Battersea. The surveyor made a contract with a barge company to take it away by river, and the cost per load was *2s. 6d.* In those days the heat of the destructor was not utilised, and the cost of disposal by fire was greater than by barge. In the case of the Shoreditch destructor, the cost of disposal by destruction was something like *2s. 6d.* per ton, and each pound of refuse evaporated one-ninth pound of water. The value of each pound of refuse as an evaporator was about equal to about one-ninth pound of coal, and its cost to Shoreditch about *2s. 6d.* per ton. As a mere fuel for evaporating water, therefore, its cost was about *22s. 6d.* per ton of coal equivalent, and Shoreditch, of course, saved entirely the cost of disposal of its dust. One of the gentlemen who spoke in the discussion, thought the municipal engineers of small towns would do well to consider the best utilisation of its refuse. To them, the question is one of cost. They have to consider if the capital charges and the cost of disposal of the refuse brings the evaporation of water for lighting or other purposes lower than the simple carriage of the dust away to a waste place, together with the cost of coal for producing evaporation for lighting and other purposes. This question again resolves itself into a question of the best utilisation of the heat in the refuse by the destructor. Mr. Russell claimed that one-ninth of a pound of water could be evaporated by each pound of refuse with the Shoreditch system. We notice in a document which lies before us as we write, that Mr. Brookman, the superintending engineer of the Rochdale destructors, claims to obtain 1·78 lb. of water evaporated from, and at 212° F. per pound of refuse by his system, and the superintending engineer of the Salford Sewage Works obtained an evaporation of 2·38 lbs. of water from, and at 212° F. per pound of refuse during a trial which lasted 14 hrs. 10 min. In the one case the result is $1\frac{3}{4}$ times better than Mr. Russell's, and in the other case it is roughly $2\frac{1}{4}$ times better. Both of them had Meldrum furnaces, fitted and used Meldrum's system of forced draught. In both cases the refuse is described as unscreened ashpit and Lancashire boiler. In the case of Shoreditch, Babcock & Wilcox boilers are installed. At Salford they have one Lancashire boiler 28 ft. × 7 ft. diam., and the flues 2 ft. 9 in. diam. Here the refuse burned during the 14 hrs. trial 18,704 lbs., the average steam pressure 50 lbs., the water evaporated per hour 2.540 lbs., which, with a good engine, is equivalent to 127 h.p. When the chimney gases were analysed it was found there was present 18·19 per cent. CO_2, free oxygen ·96, no CO. In this destructor there are firm grates, all connected, the ashpits only being divided. One large chamber is formed with a high temperature, and so fairly complete com-

bustion is obtained. To municipal engineers the question is one of efficiency. It will be for them to carefully enquire which is the most efficient system of destructor before they advise the municipal authority.

The Inventor's Eldorado . . .

We cannot say we have had great faith in the practical results of His Excellency the Chinese Minister's industrial peregrinations through the land, though it is delightful to see a thirst for information developed on so large a scale. We are, in fact, rather doubtful whether it is the chief object of this august Plenipotentiary to inspect our manufactures, or to be himself inspected; and, considering the auspices under which the tours have been made, and that in the strictest sense of the expression they are "personally conducted," we rather incline to the latter hypothesis. However that may be, this examination of British manufacturing industry through Chinese spectacles, though probably fraught with little good, can do no harm; and the other day, at least, one of His Excellency Sir Chichen Lofêngluh's business-cum-bucolic visits was so far productive that it provided us with the subject of this short article.

It was at the establishment of Messrs. Birnbaum Brothers, that in a lapsus between the toasts which appear to form a uniform feature of the programme on such occasions, the head of this well-known and esteemed firm referred in pathetic terms to the exceeding scarcity of indiarubber. So great a portion of this material, it was explained, had been diverted to the exigencies of cycles and motor cars, that the important industry of waterproofing was in a languishing condition owing to the impossibility of obtaining a sufficient supply of the staple necessary to carry it on. His Excellency Sir Chichen Lofêngluh, in his response, was happy to assure his listeners that a large stock of this commodity was being produced naturally in his native country, and that on his return thither it should receive his personal attention. With this pleasant, but distant prospect in view, the symposium broke up, its object —to use a phrase which lately has been rather frequently employed—"having been accomplished." This brief preface brings us to our thesis:—

Is it possible to produce an artificial indiarubber?

The general opinion, as represented in the multitude of researches made or being made with this object, would appear to be that it is. No other natural product, excepting, perhaps, ivory, has been the subject of so many attempts at imitation. So far, however, all, or mainly all, the investigations have been carried out on one line—the oxidation of a vegetable oil. Some of the products obtained by this method bear a marvellous resemblance to their original, and in the form of lumps can hardly be distinguished from it. Inventors, indeed, have been fairly successful up to a certain point, but there they have all stuck. They have attained almost every characteristic of indiarubber excepting one. They have secured durability, resilience, but have never been able to attain elasticity. Thus, although oxidised oil, under different proprietary titles, is successfully used in a solid form for wheel tyres and a number of kindred uses, for the pneumatic tyre it has never achieved even a remote approach to success. This lack of elasticity can be accounted for by the most cursory examination of existing processes. It appears that the solidification of linseed oil cannot be satisfactorily accomplished without incorporating with the manufactured product a certain proportion of fibrous material. The introduction of a non-elastic substance of course must be fatal to elasticity; but we are not aware that it has been found practicable to completely oxidise the oil in any other way. The latest process for producing artificial indiarubber is briefly described. It consists in saturating tow with linseed oil, the greater part of which is then exhausted in a hydro-extractor, a proportion of the oil remaining in the fibres in the shape of globules. The material is then exposed to currents of heated air, macerated in hot cylinder rolls, coloured with ochre, and the thin sheets stuck

together under heavy pressure. The product, in its main physical characteristics, is then, as we have said, indistinguishable, with the one critical exception, from natural indiarubber.

With this simple but all-important limitation, artificial indiarubber has been made. The question therefore arises whether a pure oxidised oil would possess some at least of the elasticity of indiarubber, and whether it is possible to oxidise it without mixing it with foreign materials. Whether this has, or can be done, we do not know; but we do know that the inventor who is successful in producing an indiarubber substitute having the elasticity of the natural product will find himself in possession of a potential gold mine, in comparison with which some of the richest auriferous quarries existing will be relatively insignificant.

Development of the Steam Turbine . . .

THE origin of the steam turbine is a matter of ancient history, but very little use has been made until recent years of this particular type of rotary engine. Concurrently with the introduction of the dynamo, the demand arose for an improved high-speed motor; and whilst the rotary engine is known to be, theoretically, the best which could be devised for this purpose, mechanical difficulties have always stood in the way of its adoption. About the year 1884, experiments were commenced by Mr. Parsons, with a view to the construction of a steam turbine suitable for direct coupling to a dynamo. Bearings were specially designed for minimising vibration, and the turbine first made was of 10 h.-p., and ran at about 18,000 revolutions per minute. Certain defects were noticed in this machine, but it was considered that they would not occur in the case of larger engines. In 1888 several non-condensing turbo-alternators of 120 h.-p. were constructed, running at about 10,000 revolutions per minute, and taking 35 lbs. steam per electrical h.-p. These were followed in 1892 by turbines of the radial-flow condensing type which exhibited a remarkable saving in steam consumption. Turbines of 2,000 h.-p. are now being built, and still larger sizes are in contemplation. The most recent tests as to economy indicate the consumption at full speed of only 18·8 lbs. of steam per kilowatt hour. When the steam turbine was first tried for the propulsion of steamships some difficulties arose, and the speed was very unsatisfactory, chiefly owing to the formation of vortices in the water by the propeller. Experiments made upon the *Turbinia* showed that this action might be avoided by the adoption of a screw having a coarse pitch and a large blade area. It was also found that much advantage could be derived from the employment of three engines—high, intermediate, and low-pressure—each driving one screw shaft, and each shaft carrying three screws. When alterations had been effected upon these lines, a speed of 34½ knots was attained. The destroyer *Viper* is equipped in a manner somewhat similar to that followed on the *Turbinia*, but there are two distinct sets of engines, arranged so that the vessel may travel backwards when required. Her highest speed is about 35 knots, with an indicated h.-p. of 11,000. As illustrating the ratio of steam expansion in the *Viper* engines, it may be mentioned that the inlets to the high-pressure engines are 8 in. diameter, whilst the exhaust outlets from the low-pressure turbines are 4 ft. square. Amongst the advantages presented by the turbine for steamships are comparative absence from vibration and freedom from risks inseparable from ordinary reciprocating engines.

The Case of the Mohegan . . .

IT appears from the law reports of the case of the *Mohegan* that she was an ill-fated vessel in many other respects than that of simply driving on to the Manacles. Her boilers are said to have been badly designed, and they certainly had very bad treatment, Justice Bigham saying in his judgment that the staff were a worthless lot. She was the property of the Atlantic Transport Company, and was originally designed for the Wilson line. She was of 4,500 tons burden, and de-

signed for a speed of 14 knots; her triple expansion engines were capable of developing 5,000 i.h.p. with a working pressure of steam of 190 lbs. She was fitted with four boilers, two double-ended and two single-ended, the two double-ended boilers being placed one port and one starboard, while the single-ended boilers were placed fore and aft. The material with which the boilers were made was Siemens-Martin steel, and they were fitted with Howdin's forced draught. The tubes were wrought iron of $2\frac{1}{2}$ ins. diameter outside, and 7 ft. long, and the water spaces were $1\frac{1}{4}$ in. The furnaces were 3 ft. 6 ins. in diameter, made by the Leeds Forge Company. There were three combustion chambers to each boiler, the double-ended boiler flues being divided by a brick wall of tongued and grooved bricks $2\frac{1}{2}$ ins. thick. There was a joint where the bottom and sides of the combustion chamber met, which was four plates thick. The scarph alone was $1\frac{1}{32}$ in. thick, one plate was $\frac{5}{4}$ in., and the other two $\frac{5}{8}$ in. thick each. Both sides in the dispute owned there was heavy leaking always at this joint in all the boilers. The plates were not tapered away, to cause them to meet properly, and fire was on one side of the joint all the time. Although designed to run at 14 knots her average voyage was $7\frac{1}{4}$ knots, and the Atlantic Transport Company claimed £2,000 from the makers of the boilers, Earle's Shipbuilding Company. When the boilers were made, Lloyd's and the Board of Trade surveyors were constantly about the boiler yard, and when they were finished they were tested to a pressure of 400 lbs. hydraulic pressure and passed. The vessel was classed 100 A1 at Lloyd's. In coming round from Hull to London the boilers leaked badly. She was put right, but after a time the boilers leaked as badly as ever, and a Lloyd's surveyor was brought in, and found the combustion chamber had buckled on the top, and a number of tubes and stays were leaking. They were again repaired, and the boilers tested with hydraulic pressure to 350 lbs. Now, it is hardly possible for a joint constructed as the above furnace joint was constructed, and with fierce flame playing on its one side and with water on the other, to keep staunch. The plate next the flame is almost certain to get wholly and through and through red hot. The joint is almost certain to work loose, and leakage may be expected. That the joint remained staunch under cold-water pressure proves nothing. The real test—and the only test—of a joint so constructed is trial by fire, and it appears that on the trial trip and always afterwards the joint leaked. Boilers have a normal loss, and evaporators are fitted in to make sufficient fresh water to make up for the loss. But where heavy leakage goes on the evaporators have not capacity enough to make up for that loss, and sea water requires to be pumped into the boilers to make up for the loss. The leakage was so great that the combustion chamber became an evaporator, and left the salt in the bottom in piles caked to the plates. This salt had to be picked out with the fire irons. Leaky boilers, like a noisy woman, drive men to drink, and only the chief engineer and the third engineer had minds strong enough to resist being demoralised. It was impossible to keep up steam, hence the $7\frac{1}{4}$ knots an hour instead of 14 knots. The judge decided that the engineering staff were not demoralised by the boilers, but that the boilers were demoralised by the staff. The whole question appears to be an important one for the Board of Trade and Lloyd's. Here we have a surveyor of Lloyd's who condemns the joint at the combustion chamber, and knows that it will begin to leak as soon as the flames of the furnace begin to play on it, yet he still allows the steamer to be classed 100 A1, his reason being—that it passed the hydraulic test. For a joint about 3 ins. thick, which had hot flame playing on it, the hydraulic test is not a test at all. Here, in the case of the *Mohegan*, the consequences were quite clear to the surveyor. He had, by Lloyd's rules, to grant a class for the ship because the boilers had passed a hydraulic test, although he probably knew that the joint would leak as soon as the real fire test was applied, and with a consequent speed of $7\frac{1}{4}$ knots instead of 14 knots.

Notes.

WE notice that several batteries of the Vickers-Maxim 37 millimetre automatic gun are being dispatched to South Africa. The merits of this weapon, fully illustrated and described in our issue of October last, have apparently been learnt from the enemy. So little was known about it by our war authorities that men have had to be instructed in its use by the makers before going to the front.

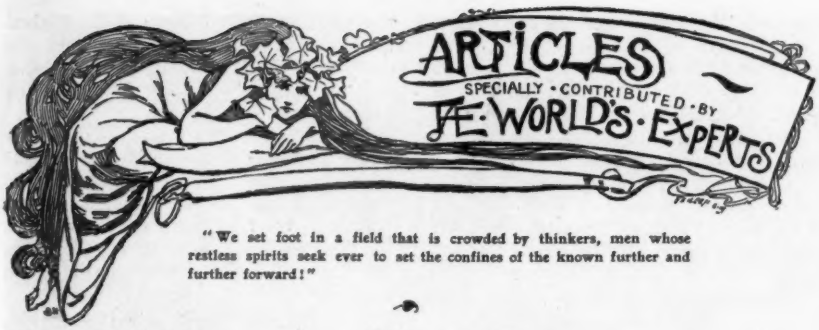
THE Automatic Railway Couplings Bill is to make its appearance before Parliament once more, and this time, presumably, with a fair chance of becoming law. The introduction of this measure is due solely to humanitarian considerations, and as its passage will have the result of entailing a very large expenditure in railway plant and alterations, it need hardly be said that it is not regarded with favour by the railway companies. The ultimate effect of the change, however, will probably be a saving in wages that will form a liberal interest on the capital expenditure.

THE Welsbach Incandescent Gas Light Company, Limited, have won their action against the Sunlight Incandescent Company, Limited, and justified the assurances they have given on the subject at various intervals to the general public. Its result involves more damage to the defendants than material benefit to the plaintiffs. It is difficult to understand the immense depreciation in the Welsbach Company's stock that has taken place within the past few months. There is nothing before the public to account for the great fall which has taken place.

THE importance of the Nicaragua Canal to American commercial interests may be appreciated by the fact that European exporters at present have an advantage over those of America of from 2,500 to 3,500 miles in distance and six to nine days in time. On the opening of the proposed inter-oceanic canal, Philadelphia, Boston, and Baltimore would be nearer by water route to all points north of Hong Kong, such as Shanghai, Tientsin, Kobe, Yokohama, and Vladivostock. To cities south of Hong Kong, American cities would be about on an equality with Europe; whilst to Australia, New Zealand, the Pacific Islands, and the western coast of South America, American merchants would be nearer their European rivals. The canal then must prove a factor of immeasurable importance to trade in the far East and the British Colonies in the Pacific.

ANOTHER London electrical railway—or at least the conversion of a steam-propelled line to an electric one—is promised; and again we are told it is not possible to get the plant made in this country, and that we shall have to go to the United States for it. The repetition of these announcements in connection with almost every electrical traction installation of an important character, appears to us very humiliating. Our electrical engineers, we believe, can hold their own tolerably well in electric lighting, but heavy traction seems out of their line. It must not be forgotten that by sending these orders to the United States Americans are gaining from us something even more important than trade. They are gaining experience, and at our expense. Every order of this kind taken away from British engineers renders it more difficult for them to execute another of the same kind. Could not one of our large firms make a desperate attempt to undertake such work?

THE "Energising Momentum Engine" has been placed before our attention in a voluminous bundle of printed matter purporting to explain the principles of what is described as a new "power." We must own the explanations afforded of this new source of energy appear to us a little obscure. Messrs. Maudslay, Sons & Field, Limited, we understand, have removed the plant. It would be interesting to know whether its installation in their works preceded or followed the advent of the Official Receiver.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

The Making of a Glow Lamp.

By C. J. ROBERTSON, A.M.I.E.E.

MR. ROBERTSON was born in 1860 and educated at the Charterhouse and Merchant Taylors' Schools, London, and at Finsbury Technical College. On the opening of the Lane-Fox Lamp department of the Anglo-American Brush Co. in 1881, Mr. Robertson joined as a pupil, and after a short time obtained charge of the testing department. In 1883 he left the Brush Co. to take up a position as assistant-manager of the lamp department of the Pilsen-Joel and General Electric Co., of London. In April, 1885, he left the Pilsen Co. to join the Bernstein Co. Owing to threatened litigation, Mr. Robertson, at the end of 1886, left the Bernstein Co. to equip and manage a new works in Holland. He remained in management of this factory until March, 1891, when he left Holland for Vienna, where he had previously entered into partnership with two Viennese gentlemen for the erection and management of a new lamp works there. After designing and equipping these works, Mr. Robertson produced the "Watt" lamp, and the works became one of the largest on the Continent.

In England Mr. Robertson and some friends formed a semi-private company, called the Incandescent Electric Lamp Co., Ltd., and on the expiration of the Edison Lamp patents, the Brook Green Works, Hammersmith, W., were acquired, Mr. Robertson being appointed technical and managing director. Mr. Robertson is an Associate Member of the Institute of Electrical Engineers and a Member of the Austrian Institute of Electrical Engineers. He has made many contributions to the various electrical journals, chiefly on incandescent lamps, and collaborated with Mr. Byng in his paper on high voltage fittings read before the Institution of Electrical Engineers in 1897. He has also taken out several patents relating to processes for, and manufacture of, incandescent lamps.

To the superficial observer nothing could be simpler in its physical essentials than the dainty electric glow lamp we see in such numbers around us. What, indeed, is a glow lamp? Just a glass bulb without any air inside it, and a loop of carbon filament fixed in the interior. Simple indeed. But how many

years of laborious experiment; what a concentration of inventive genius, and what enormous sums have been dissipated in arriving at this simplicity, few people know. And now, when the goal pursued so ardently and so fruitlessly through so many years of frustrated endeavour has been attained at last, note the multitudinous processes, bristling with examples of the highest inventive faculty, which are required to bring the one aim of the last sixty years into a living reality!

The earliest mention of an electric glow

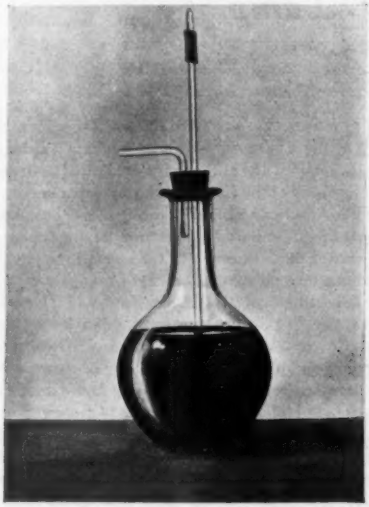


FIG. 1.—CELLULOSE SOLUTION READY FOR SQUIRTING.

lamp was in 1836. The first to patent such a lamp was Dr. Moleyns, in 1841, who used incandescent platinum in a vacuum.

A further advance was made by J. W. Starr in 1845 who, through his agent (King), patented the use of carbon heated by electric current to incandescence in a vacuum. The next step was by Roberts, who in 1852 first pointed out that the carbon conductor should be made as thin as possible, and in a vacuum as perfect as possible.

Up to this period primary batteries were the only source of current, and this method being very costly it was not until the dynamo of Gramme became a commercial success that any real want was felt for the incandescent lamp.

It was then that inventors directed their attention to obtaining substances capable of being subdivided into small units of light, and one of the earliest patents pointing out the essentials of economic lighting by small incandescent lamps in parallel is that of Lane-Fox in 1878, who advises a pressure of about 100 volts.

The next patent is that of Edison, in 1878, wherein he goes over much the same ground, but in 1878, Sawyer and Mann point out that the use of carbon in a vacuum is generally known, but they describe for the first time a process of "flashing" for making carbon by heating it in a carbon containing gas as a liquid, they also describe the important process of ridding carbon of its occluded gases by heating it in a carbon-preserving atmosphere; their filament, however, was of low resistance, and used in nitrogen gas and not in a vacuum.

The lamp which most nearly approaches that which is in use to-day is that of Lane-Fox, of 1879. He there describes the use of high resistance filaments, regulated by the Sawyer-Mann "flashing" process; this is again followed by Edison with his patent of 1879, covering much the same ground, except that in this patent, and in another of the same year, he first introduces cotton thread, wood splints and millboard as suitable for obtaining high resistance carbon filaments. The next names of note are those of Swan, 1880, where he mentions the parchmentising of the cotton thread, and that of Lane-Fox of 1880 for a complete lamp and processes of manufacture.

It will therefore be seen that the three most prominent names connected with the evolution of the present-day lamp are St. G. Lane-Fox, T. Edison, and J. W. Swan.

Lamps made by each of these last inventors were almost simultaneously placed on the market about 1881. From this period steady progress was made in the perfection of the various details of

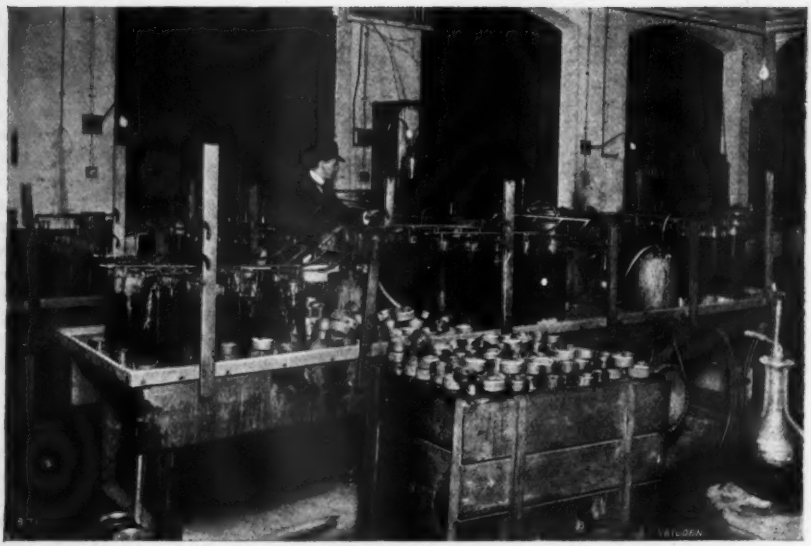


FIG. 2.—CORNER OF FILAMENT LABORATORY, SHOWING FILAMENT BEING SQUIRTED INTO TALL GLASS JARS.

manufacture, more especially in the composition and process of manufacture of the carbon filaments.

The key to the electric glow lamp was contained in the filament, its composition and treatment. What was required was a substance that should give a very high resistance, and the united product of the researches of Edison & Swan gave rise to the establishment of a monopoly in the only form of practical electric glow lamps made in this country that lasted from 1887 to 1893.

A solution of cellulose forms the material now invariably adopted for the carbon filament. This cellulose may be cotton-wool or wood fibre dissolved in a solution of chloride zinc; others use cotton converted into gun-cotton and dissolved in collodion or acetic acid. The solution is then forced under air pressure from the flasks shown in Fig. 1, through graduated jets into a "setting" liquid, where it assumes the form of a semi-solid gelatinous thread (Fig. 2.) The precipitated thread is removed

FIG 3.—SQUIRTED CELLULOSE THREAD IN BASKET.

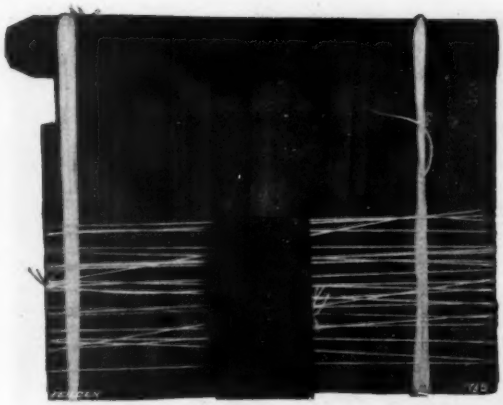


FIG. 4.—CELLULOSE WOUND ON CARBON BLOCK READY FOR CARBONISING.

into the baskets shown in Fig. 3. The operations of forming and treating these threads are of the greatest nicety.

The quantities of cotton and the gravities of the various solutions used have to be kept very exact, and the temperature of the solution must also be kept within narrow limits. Devices are installed to facilitate this necessary exactness being maintained. There are indications when the subsequent filtration and evaporation of the solution (under *vacuo*) are complete, and from the appearance of this solution a good idea can be formed as to the quality of the resulting thread. Pressure is now used for the ejection of the mass from strong glass vessels through jets, and this pressure has to be regulated to various amounts to suit various diameters of thread required; and the diameters of the jets through which this mass is squirted are measured off to great exactness. The "setting" liquid is alcohol, and this is used to solidify the ejected mass and its strength requires careful adjustment. The material thus formed is subsequently treated in chemical baths, and this is carried on for a certain definite period, any departure from these details leading to bad and wasteful production.

After treatment in chemical baths, the thread or filament is washed and dried, and then takes the appearance of a clear cat-gut violin string. In this form it is exceedingly tough, and lends itself readily to being wound on the variously shaped carbon blocks or formers, which is the next operation (see Fig. 4). For this purpose small machines are used for revolving the carbon blocks, the operator guiding the threads and fixing them to the blocks when filled.

The foregoing and subsequent processes, as described, relating to the manufacture of incandescent electric lamps, are mainly those carried out by the Incandescent Electric Lamp Co., at Brook Green, Hammersmith. The operations carried out in the course of the production of the high-class "Robertson" lamp may be considered representative of the most advanced practice in this industry.

The above-mentioned carbon blocks are now packed in plumbago pots, and covered with carbon powder to prevent oxidisation. These pots are placed in the first heating furnaces, and gradually heated up for 24 hours; subsequently they are removed to second heating furnaces, where they are raised to the intensest heat by means of petroleum and coke for about another nine hours, the temperature being carefully watched through the whole period. When cold, the pots are removed from the furnaces and the blocks removed from the pots. The filament, after cooling, has been con-

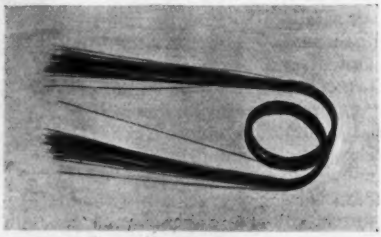


FIG. 5.—BUNDLE OF CARBONISED FILAMENT.

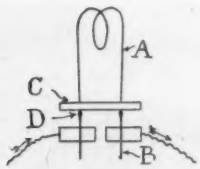


FIG. 6.—DETAIL OF JOINTING APARATUS.

verted into the purest carbon—steely-black in hue, very elastic, and almost as hard as a diamond, seeing that it will scratch glass and appear as shown in Fig. 5. After being gauged with micrometer gauges, the filaments are ready to be affixed to the metal conductors, or leading-in wires, whose office it is to convey the current through the glass globe to the filament inside. This conducting metal must possess these important properties: it must have a high melting point to withstand the heat of the glassblower's flame; it must be unoxidisable when in these flames; and, above all, it must have the same coefficient of expansion as the glass through which it passes, otherwise there would be crackage of the globe. The only material yet known which fulfils these conditions is platinum. Platinum, in the form of wire, is first cut into lengths by automatic electrically-driven machines, which cut and count some 2,000 lengths per minute; the cut wires have one end flattened which, passed through a draw-plate, converts the flattened end into a tube, and the filaments having been gauged and cut to a fixed length, according to their diameters and the volts and candle-power of the lamps to be made, are inserted in these tubulated platinums.

The next operation is one of the greatest ingenuity and interest. It consists in depositing hard carbon over the juncture of the wire and filament. This operation has been elaborated in great detail, with the view of obtaining constancy in results, expedition, and safety to the operators. The filament is placed in a machine (Fig. 6), which allows an electric current to pass from one wire across one junction, then through a short circuiting piece to the other junction, and so on to the other wire. When the filament is placed in the machine, the latter is dipped into a well containing benzine (a liquid hydrocarbon), and at the same time the circuit is automatically closed (see Fig. 7). Heat is generated at the points of junction between the filament and platinum wires, and carbon is deposited from the benzine at these places, the filament being thus sealed securely to the wires. A general view of this process is shown in Fig. 8. After examination the filament, now attached to its platinum "leads," is taken to another department to have its electrical resistance reduced and adjusted to an exact ratio. This process of reduction, sometimes called "flashing" or "treating," was, as we have previously stated, invented by Sawyer & Mann, although Maxim has on different occasions placed on public record his claims to the invention. It was

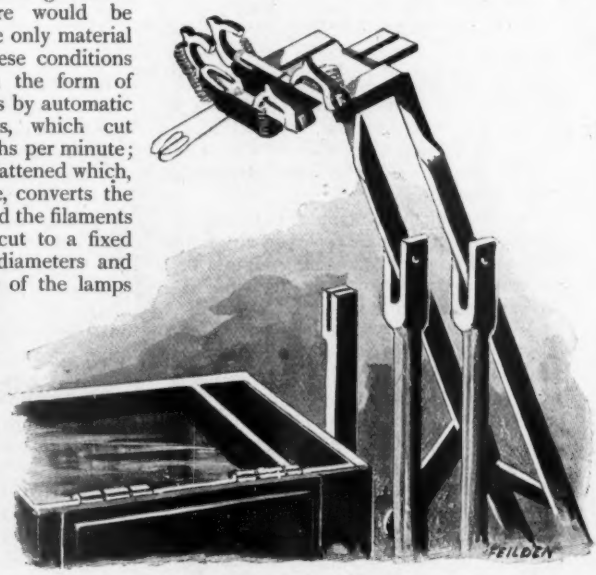


FIG. 7.—JOINTING APPARATUS, SHOWING BENZINE RECEPTACLE.

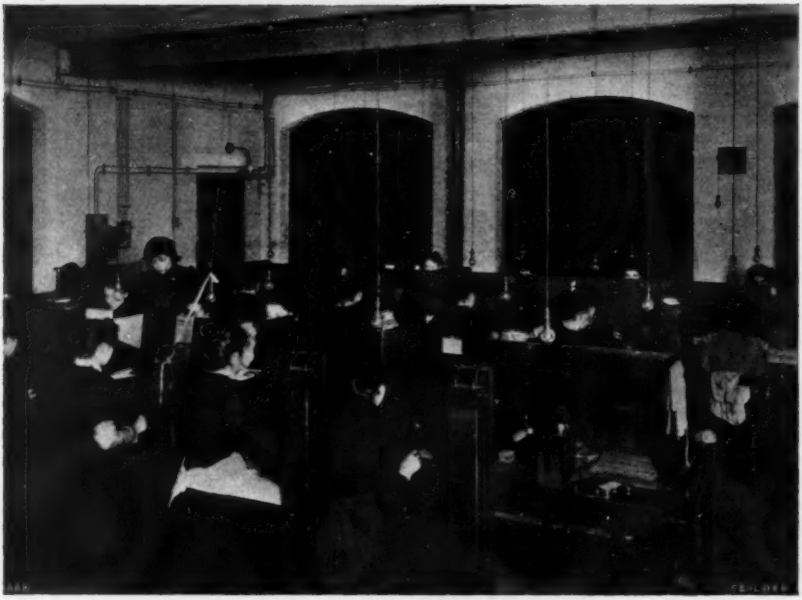


FIG. 8.—PORTION OF JOINTING DEPARTMENT, SHOWING REGULATING RESISTANCE TO LEFT OF OPERATOR.

used by Sawyer & Mann for lamps with low-resistance filaments and filled with a neutral gas, but was first used for high-resistance filaments *in vacuo* by Lane-Fox and Maxim, whose methods are practically those in use to-day.

In "flashing," the filament is placed in a holder under the receiver of an air-pump (Fig. 9). The receiver is exhausted of its air, and afterwards filled with an attenuated hydro-carbon vapour derived from benzine. These operations are controlled by only one handle, and gauges are used to ascertain and regulate the degree of exhaustion, &c. A powerful electric current is now passed through the filament, which is heated to a high degree of incandescence, causing a deposit of carbon on it, the high temperature having split up the hydro-carbon vapour into carbon and hydrogen. The former is deposited where nascent; the latter is carried away by the air-pump.

The final resistance to which the filament is reduced is ascertained on a Wheatstone bridge with a zero galvanometer. A general view of this Department is shown in Fig. 10.

In the foregoing operation of "flashing" any thin places in the filament naturally become the hottest, and therefore receive the greatest deposit of carbon; consequently the filament attains an even cross-section throughout its length. At the same time, it is made more homogeneous and lower in specific resistance. The filaments are now carefully checked and examined by other operators preparatory to their being sealed into the glass bulb.

The manufacture of glass bulbs is in itself an industry, and only specially trained hands can be employed. As a matter of fact, the question of labour in incandescent electric lamp manufacture has been a most serious one. The industry was one which, on its establishment, did not lend itself but in a very small degree to previous experience. Hence, generally, all the operators have to be trained at the

expense of their employers, such education extending over some months and entailing a large amount of wastage in material and instruction before a satisfactory lamp is produced by the operator.

The glass bulb as received from the glass house, and in its subsequent developments is shown at Figs. 11 to 14. The end of the protuberance (Fig 11) is heated in a blow-pipe flame, and a small tube or stem (for the subsequent exhaustion of the air) is here attached. The other end of the bulb is now heated and drawn off, and an opening made for the filament to be passed into the bulb (Fig. 12). The platinum wires whilst resting on the extreme edge of the opening are affixed thereto by the blow-pipe flame, and this end of the bulb is worked up into the shape shown in Fig. 13. A ridge with two cross pieces is formed at the sealed end, in order to provide a secure fastening to the brass cap which is subsequently affixed by cement. The platinums are subsequently bent up into loops as shown, and the lamps are allowed to cool down in an annealer. These operations and bulb-blowing are shown in Figs. 15 and 16.

The lamp is now ready to have its air exhausted; so after examination each batch goes to the exhausting or pumping department, where by means of the glass stem they are hermetically joined to tubes connected with Sprengel mercury pumps (Fig. 17). These tubes are arranged in groups of five to a fork, each fork being connected to one pump. A preliminary exhaustion, however, is made by mechanical pumps, and during the operations the lamps are strongly heated by gas burners, and a desiccating material is used between each group of five lamps and the pump. The mercury pump used at the Brook Green Works is a form of the Sprengel, and may be described as follows:—Mercury falls from an upper reservoir to a tube with five small jets on its underside. Opposite each of these jets is a vertical tube of fine bore, funnel-shaped, at the top end nearest the jets. The mercury coming from the jet in a fine stream breaks up more or less into globules, and falling on the sides of the funnel-shaped tube imprisons air beneath it; the globule continues to fall by gravity and, as it gradually enters a narrow tube, it eventually assumes a piston shape, and successive globules form successive pistons with air enclosed between them.

A. Filament in clip.
B. Receiver to be placed over *A*.
C. Hydro-carbon generator.
D. Current regulator.
E. Vacuum gauge.
F. Galvanometer.
G. Wheatstone bridge.

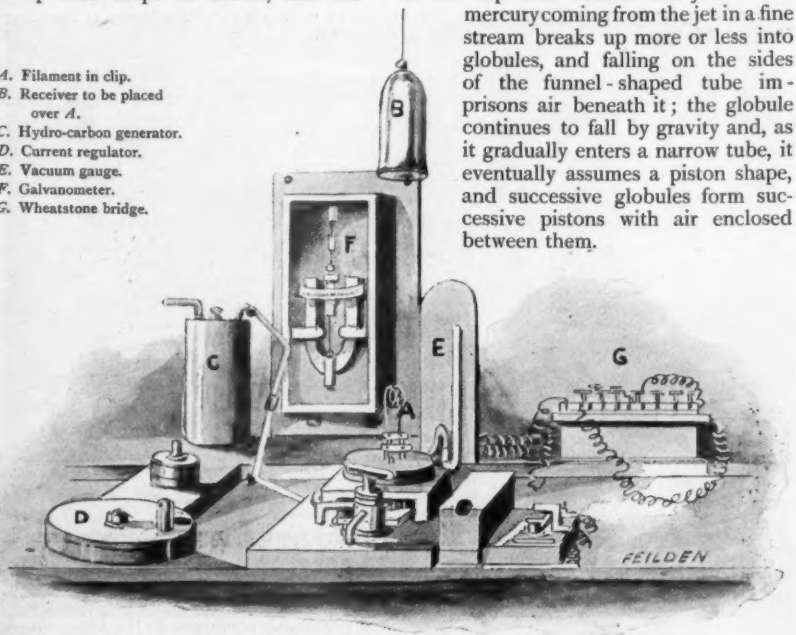


FIG. 9.—FLASHING APPARATUS.

FIG. 10.—FLASHING DEPARTMENT, SHOWING COMPLETE SET OF APPARATUS FOR ONE OPERATOR IN FOREGROUND. SEE ALSO FIG. 9.

The first part of the chamber, into which the mercury jets enter at the top of the pump, is connected to the lamp to be exhausted. The lower ends of the five vertical tubes are connected to a chamber attached to a vacuum pump;

FIG. 11.

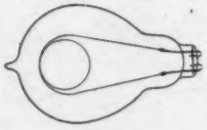


FIG. 14.

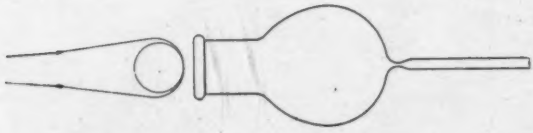


FIG. 12.

FIG. 13.

the latter removes the air and gases carried down by the mercury pistons. The mercury flows off from this chamber into a lower reservoir, and from the latter is raised automatically to the upper reservoir previously mentioned; the foregoing operations are again gone through *de novo*, and

the mechanical pump just described is so arranged that it exhausts quite 99 per cent. of the air from the lamps, leaving only a final one per cent. to be exhausted by the mercury pump, thus considerably shortening the operation. The mercury pump alone would take many hours to properly exhaust a lamp.

When well exhausted a gradually increasing current is sent through each lamp, to drive off the occluded gases in the filaments and wires. To ensure the complete removal of these gases, and to make a perfect vacuum, an excess of current is passed through the lamps until they are running at a voltage far exceeding that at which they will be finally used. Voltmeters are used for this purpose, and to ascertain when the vacuum is perfect there are gauges to each pump, and each worker is provided with an additional check consisting of an electrostatic arrangement, which gives an indication of an imperfect vacuum in the lamp by glowing similar to a Geissler tube. It is not generally known that the vacuum in a glow lamp is more perfect than that of a Röntgen tube, and that in fact it is about the finest it is possible to obtain by any means. The lamps are now removed from the pumps by means of small blowpipes, with which the operators melt the end of the small glass exhausting stem next the bulb. The lamp now appears as in Fig. 14.

The lamps are now checked by another vacuum test, and then passed to the testing department (Fig. 18), where they are first examined, and then hung in rows on an electric conductor and tested with current for any defects in the carbon mounts, bulbs, &c. Another vacuum test is made, and the lamps then enter the photometer room (Fig. 19), where two operators compare each lamp against a standard light on a photometer bar fitted with a Joly prism. As the current for photometry must be steady and invariable, the ordinary current

FIG. 13.—CORNER OF GLASS-BLOWING DEPARTMENT.

FIG. 16.—OPERATOR BLOWING LARGE BULBS.

is not used, but current from a large battery of accumulators is devoted to this purpose.

To ensure that the lamps shall all run well together and have the same average life, the photometry is so arranged that all the lamps are incandesced to the same efficiency or number of candles per watt. A "high efficiency" lamp is, therefore, one which gives a large number of candles per watt, and is consequently a bright lamp, and a "low efficiency" lamp is the converse. The method of photometry resorted to in order to produce this result consists in running the test lamp up to a certain brightness, until an approximate candle power is read off on the photometer.

The wattmeter is next read off; and this instrument is arranged with two scales, one being a scale of watts, and the other a scale showing these watts when divided by a certain "efficiency," viz., $3\frac{1}{2}$ watts per candle power. The current through the lamps and its distance from the prism are both regulated so that the same candle power is read on the photometer bar as on the wattmeter scale, when the prism shows equal illumination. The pressure necessary to bring about the balance of these conditions, is read off on a voltmeter. Every lamp is so tested, and has its voltage and candle-power written on the bulb; for example, a lamp is balanced on the photometer bar, and on the wattmeter (when the latter is read on the $3\frac{1}{2}$-watt scale) at 16 candle-power, and requires—say, 100 volts to give this balance. The lamp is marked with 100/16, and by multiplying the 16 by $3\frac{1}{2}$, we have 56 the total watts; and by dividing this again by 100, we have 0.56 the current.

After leaving the photometers, the lamps are sorted into classes, and then passed in trays into the capping department, to be fitted with the various caps or fittings which are ordered. Quite 95 per cent. of the caps used in England, are the bayonet caps. There are other caps, such as the Edison screw, central contact, etc. The method of fixing these caps to the bulbs is generally by cement, which, in the case of the "Robertson" lamp, is a special preparation. This cement, when dry, resembles marble, and is capable of withstanding the highest temperatures and any degree of damp without deterioration. The finished lamp, being first tested in a holder for goodness of contact, symmetry, and gauge of caps, then go into a drying room where they are left for four or five days. Another vacuum test follows, which is succeeded by a "running" test at full

candle power in the actual holders to be used by the consumers (Fig. 20). The lamps are then cleaned and stamped with trade-mark, voltage, candle-power, and efficiency. The lamps, as a final operation, are submitted to a last vacuum and "running" test to check the branded figures. The lamps are then packed in corrugated wrappers.

Having now concluded this brief survey of their manufacture, some general observations on electrical incandescent lamps may not be out of place in this article.

The electric incandescent lamp is simply a transformer of energy; and the vibratory motion of the ether which it produces (felt by the eye as a luminous sensation), requires a calculable supply of energy for its support. With ordinary artificial illuminants, this energy is taken from the combustible: in electric glow lamps it is furnished by the electric current. The transformation of this energy is, in each instance, accompanied by a loss. The mechanical efficiency of a source of light is that number which indicates what is the fraction of the total energy expended, as compared with that portion which is capable of producing a luminous impression. The mechanical equivalent of an incandescent lamp varies in general practice from $2\frac{1}{2}$ to $4\frac{1}{2}$ watts to give one candle-power. Annexed is a table which gives the mechanical equivalent of the candle-power obtained by the best known illuminants:—

Gas burner (Butterfly)	consumes 93 watts	to give 1 c.pr.
Candle	consumes 86 watts	to give 1 c.pr.
Oil lamp	,, 57 ,,	,, ,,
Incandescent electric lamp	,, from $2\frac{1}{2}$-$4\frac{1}{2}$,,	,, ,,
Enclosed arc lamp	,, ,, $2\frac{1}{2}$-4 ,,	,, ,,
Arc lamp	,, ,, 0·8-$1\frac{1}{2}$,,	,, ,,

The first three on the above list have an extremely low efficiency, owing to the enormous losses undergone in combustion. The production of light in all burners, is due to the same cause; the incandescence

FIG. 17.—CORNER OF PUMP ROOM, SHOWING PROCESS OF EXHAUSTION BY SPRENGEL PUMP.

of carbon. In the first three, the luminous body is the particle of carbon not yet consumed, and whose incandescence is maintained by the combustion of the gas. With these illuminants there are heavy losses due to incomplete combustion and convection of heat to the surrounding air. With the electric incandescent lamp, on the other hand, the incandescence is maintained by the electric current; and as the incandescing material, or filament, is in a vacuum, there is no loss by convection, but only by radiation. The temperature to which the carbon particles in each of these sources can be raised, determines their brightness and mechanical efficiency.

Although the glow lamp appears, from the above table, to be so efficient in comparison with the other illuminants, yet the luminous or optical efficiency of all these six sources is very low. When any body is below 480° C., its luminous efficiency is zero, as the vibrating movement of the ether is not rapid enough to be sensible to the eye as light. When we compare the arc lamp with the coal used for the generation of the current with which it is supplied, after allowing for all losses from the coal to the engine, dynamos, lamps, etc., we get an optical efficiency of barely 1 per cent.

With electric glow lamps, the number of candle-power obtained from the watt (its efficiency) can be anything one chooses, according to the temperature at which the filament is run. With a filament of given dimensions, this depends upon the voltage at which it is run; but it must be remembered that the higher the efficiency or temperature of a lamp, the shorter is its life. Owing to the various costs of energy (Board of Trade units) there is a particular efficiency at which to run a lamp on any circuit in order to obtain the greatest economy in running expenses made up of (1) the cost of energy; and (2) lamp renewals.

FIG. 18.—TESTING AND EXAMINING THE LAMPS FOR VARIOUS DEFECTS.

In order to ascertain the best efficiency at which to burn electric lamps, so as to obtain the maximum degree of economy, the writer has ascertained by experiment what the length of the life of the various efficiencies is. For this purpose, many tests were made on a large number of "Robertson" lamps, run on an average central station circuit, and readings of the watts used and candle-power given were taken every 50 hours. A calculation was then made of the total expenditure for energy used and lamps renewed during the period of the test. The life of all lamps was considered at an end—*i.e.*, they required renewing—when they had lost 25 per cent. of their original candle-power. By making these experiments at various efficiencies, calculation shows which lamp gives the greatest economy. In deciding the merits of a lamp, it will be seen that account must be taken, not of its mere initial efficiency, but of its mean average efficiency during the whole of its life. Some lamps show a good efficiency at the start, but after a few hours' run they rapidly fall off. As the result of extended experiments I have arrived at the following conclusions:

FIG. 29.—DETAILS OF A PHOTOMETER ROOM.

The operator is looking into a dark box containing the Joly prism; her right hand regulates distance, whilst her left hand regulates the current. Further to her right is another operator reading the voltage.

1. Where the Board of Trade unit is sold at 4d. to 2d. and on a supply circuit of average steadiness, the best lamp to use is one of 4 watts per candle power.
2. Where the Board of Trade unit is from, on a supply circuit of average steadiness, 4d. to 6½d., the best results are obtained by a lamp of 3½ watts per candle-power. If the circuit is of exceptional steadiness 3½ watts gives the best result.
3. Where the cost of Board of Trade unit is from 8d. to 6½d., and if the supply is exceptionally steady, lamps of 3 watts per candle-power give the best results.

With regard to the position of artificial lighting, little progress, from a physical point of view, has been made from the beginning of civilisation, when the savage used a resinous torch whose luminous efficiency was nearly equal to that of the arc lamp. There seems to be a practical limit in obtaining light by incandescence, owing to the fact that the eye becomes fatigued, and is harmed by increasing the temperature of incandescence. Some of the alkaline earths withstand higher temperatures than will carbon without fusion; yet the light thus produced is so dazzling that it must be subdued by coloured and other globes by which time the efficiency is no greater than that of carbon.

It may, however, be possible to find a substance other than carbon, which will emit at the same temperature a greater

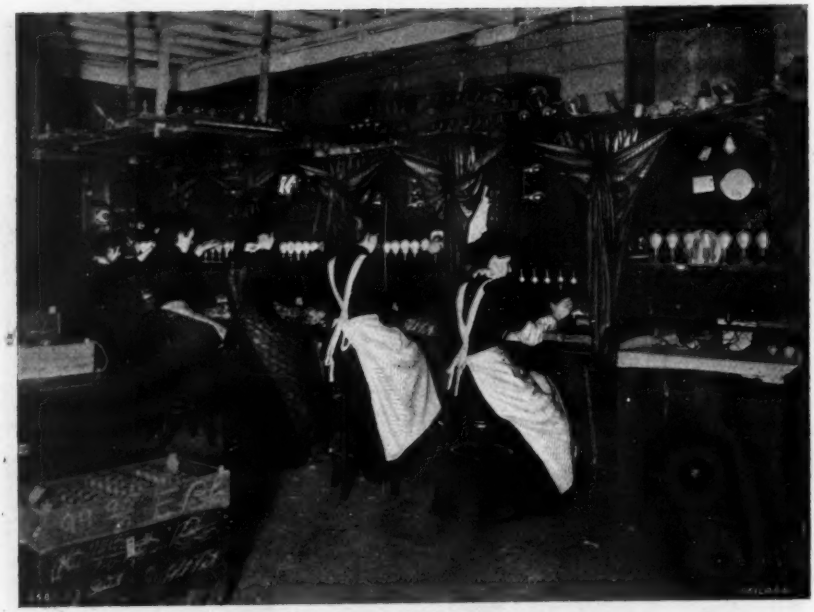


FIG. 20.—PRELIMINARY RUNNING TEST IN ACTUAL HOLDERS.

quantity of light, but the prospect of so doing does not at present appear hopeful. More promising sources of illumination seem to be denoted in the researches of Professor Langley with fireflies. The measured energy of these insects is found to be expended entirely in the visible part of the spectrum. Staub has found that the efficiency of a Geissler tube is 32 per cent., or more than six times that of an electric glow lamp. The quantity of light produced by this agency is, however, too minute to be of practical use, although the demonstrations of Tesla and of Moore have shown that great improvements are possible in this means of illumination. A method of obtaining artificial light which appears invested with possibilities is that of bombarding the oxides of the alkaline earths by means of cathode rays, as in the lamp of Professor Ebers. The defect of these lamps is that the oxide changes into the metallic state.

Phosphorescence and fluorescence are assumed to be due to a class of vibrations distinct from those which cause incandescence, and it may be found possible to excite phosphorescence (luminescence) directly by electrical means. From Maxwell's hypotheses it may be inferred that the most efficient light would be obtained if one could vibrate the molecules at a period equal to that of luminous undulations; and it may one day become possible to effect this direct from electrical vibration.

C. J. Robertson.

The Balloon as a War Machine.

By H. LAWRENCE SWINBURNE.

❀

"Beautiful invention; mounting heavenward, so beautifully, so unguidably, emblem of much, and our Age of Hope itself."

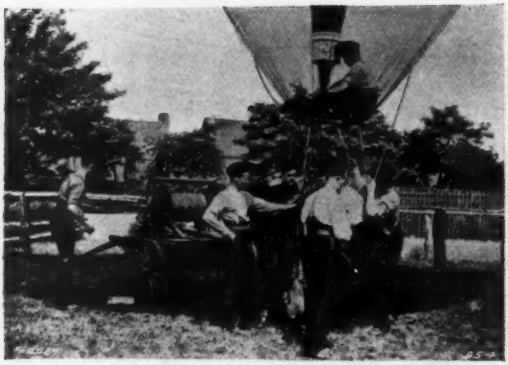
❀ ❀ ❀

MR. SWINBURNE is a prominent authority on subjects connected with Naval and Military operations. His early life was spent in India, and he served through the Afghan campaign of 1878-80. He has rendered a conspicuous service in his clear exposition of the Naval Manœuvres, all of which, since the year 1892, he has attended with the Fleet in the capacity of special representative of both the *Daily Chronicle* and *Standard*. The papers read by him before the Royal United Service Institution, and his reports on the Dockyards, Arsenals and Navy of the United States excited much attention. His aëronautic experiences have been unique, in that, in company with Mr. Percival Spencer, he successfully crossed the Channel. The ascent was made from the Crystal Palace, and the balloon, under the able management of Mr. Percival Spencer, settled some four miles from Havre, after having covered a distance of 150 miles in five hours, and attaining an altitude of 6,900 feet.

❀ ❀ ❀

IT is true that "free" ballooning is part of the training of the military aëronaut. It is, moreover, more than probable that the use of free balloons—either wind-guided or steered—will some day be utilised for war purposes. For even a wind-guided balloon can often be brought to a given spot by ascending or descending, so as to get the required currents of air. Colonel Templer, that most celebrated of military aëronauts, has embarked on several voyages in which he has started with the definite object of descending at a given point, and has done so with complete success. He has in this way guided, so to speak, his balloon from the Crystal Palace to Barnet, from the Crystal Palace to Aldershot, from Southall to Harrow, etc. Again, during the American Civil War, an aëronaut ascended from McLellan's camp on the Potomac and drifted over the enemy's lines at a height of one and a half miles, and made a perfect observation of their position and all their movements. By rising into a contrary current of air, he was enabled to retrace his path, and to descend safely within his own lines. Presumably he used a pilot balloon, and ascertained that the upper current would bring him back, for we are told that he purposely cut the retaining rope, and turned his balloon from a "captive" into a "free" one. If this was not so, luck was evidently a big factor in his success, as he could have had no certain knowledge of the direction of the upper currents.

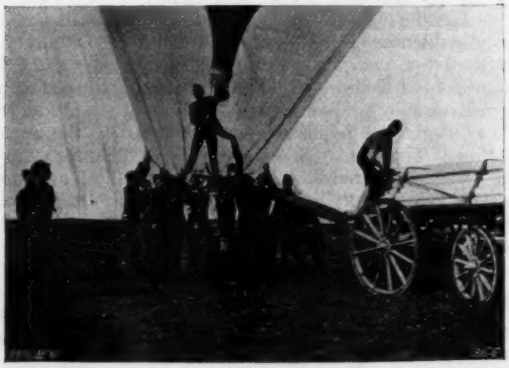
In fact, to guide balloons by using ascent and descent to obtain different currents of air, the use of pilot balloons, or a "satellite" balloon, would be essential to accuracy. This latter would be weighted



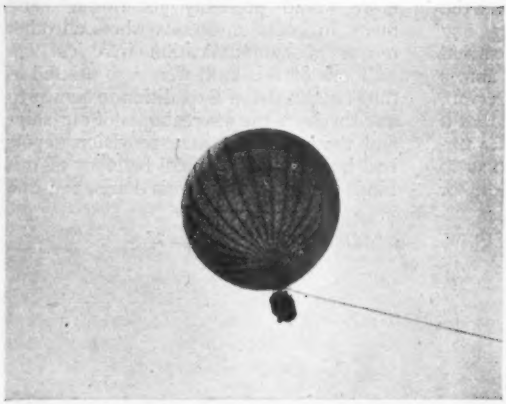
PREPARING FOR AN ASCENT, SHOWING WINDLASS, DRUM AND CARRIAGE ON WHICH BALLOON CAN BE TOWED.

as required, whether to ascend or descend, and attached to the aëronaut's balloon by a very light line, say 1,000 ft. in length, and thus the direction of the neighbouring currents of wind observed. A useful pilot balloon would contain about 200 cubic feet of gas, and would be easily discernible at 2,000 ft. or more above or below the aëronaut's car. As regards the number of different currents and the varying force and direction of the wind, Colonel Templer, who, perhaps, has experimented more in this direction than any other aëronaut, has put on record the following. "My experience teaches me that you generally find three currents in 5,000 ft. elevation. It will then depend on their variance as to where you can take the balloon." In the balloon in which M. Tissandier left Paris during the siege, those in the car were no less than ten hours in the air, a time in which, with even a very light wind, they should have travelled a very considerable distance, and yet they only landed a few leagues distant from Paris. The ascent was at night, and they believed, and it was very possible, that they had crossed and re-crossed Paris several times in the darkness, encountering different contrary currents at the various altitudes to which the balloon ascended or descended.

One of the difficulties of guiding a balloon on the system of rising or descending until a current of air travelling in the required direction is reached lies in the fact that, to obtain whatever altitude may be required, there must be an expenditure of gas to descend, or ballast to rise, thus consuming the two essentials, which in combination, form what may be termed the life blood of the balloon. Captain Baden-Powell, one of our practical military aëronauts, has suggested a method by which the waste of ballast and gas might in a measure be avoided, which, though as far as I know, never practically adopted, has the merit of distinct ingenuity. A safety-lamp carried in the car has attached to it a tube, which at the other end connects with a small balloon in the interior of the large one. This tube and smaller balloon might be either of balloon material or of very thin aluminium. When the lamp is lighted the air in tube and small balloon is heated, thus raising



REFILLING, SHOWING CYLINDER WAGON AND HOW BALLOON IS FILLED FROM CYLINDERS.

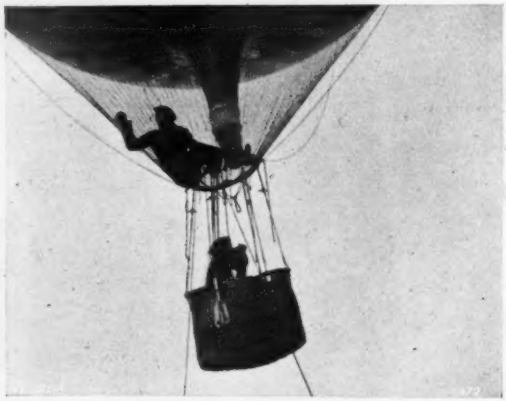


BALLOON IN HIGH WIND. (THE TETHERING ROPE CAN BE SEEN ON THE RIGHT-HAND SIDE OF THE PICTURE.)

the temperature of the gas in the large balloon. It is evident that the gas in the large balloon can be heated or cooled as required by either turning up or down the lamp or removing the tube, and the balloon will accordingly ascend or descend. For example, if the balloon be one of 25,000 cubic feet capacity, and the temperature of the gas raised one degree, the gas will expand one five-hundredth of twenty-five thousand, *i.e.* 50 cubic feet. This will be equivalent to displacing 50 cubic feet of air, giving the balloon the same increased buoyancy as would be gained by the discharge of 3·8 lbs. of ballast. Another difficulty in the way is the keeping of the balloon for any length of time at the exact altitude at which the desired current of air affects it. So delicately balanced is the machine that the slightest change of temperature affects it, even that caused by a passing cloud obscuring the sun. The heat of the sun's rays causes immediate expansion and ascent, whereas any cooling of the air temperature acts in the contrary way equally instantaneously. The writer had a very good example of this in a trip across the Channel from Beachy Head (to Fécamp), made to test Andrée's steering appliances. It was the 20th of December, and a bright, but cold day. To test the gear it was necessary to come down, so that a large portion of the 500-feet trail rope was water borne. Our object, in fact, was to keep some 200 ft. above the water. The air being immediately over the water, the balloon cooled so rapidly that it was only by incessant dribbling out of ballast that the balloon could be kept from actually falling in the water.

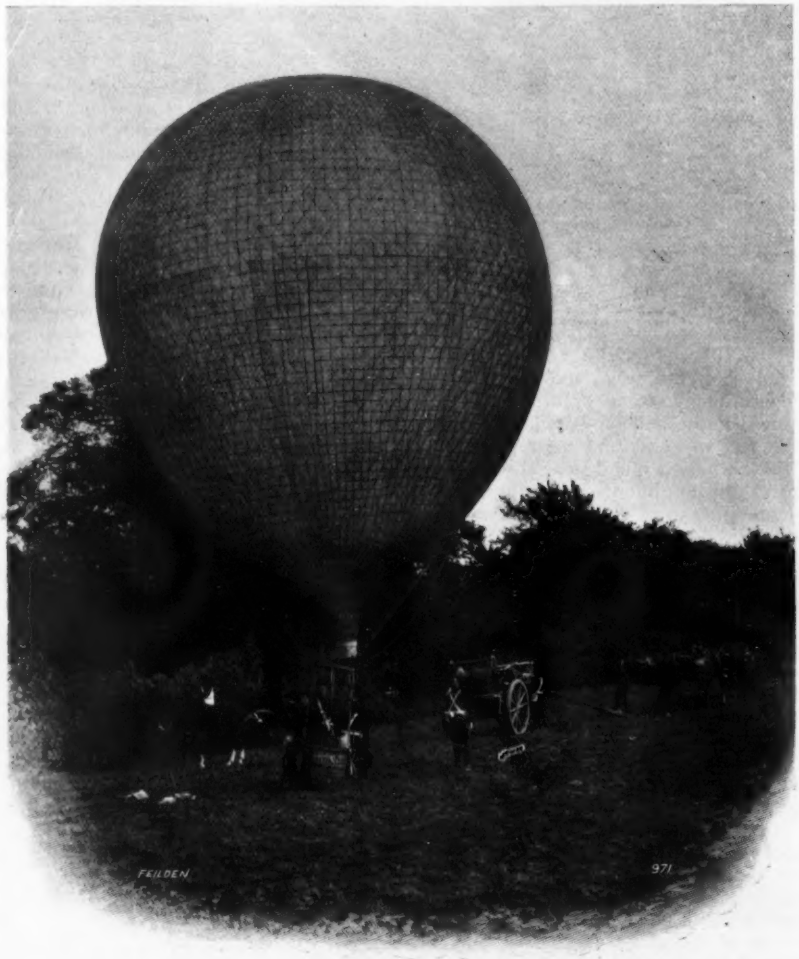
Mr. Spencer, the aëronaut, whom I accompanied, managed this with wonderful skill; but once we actually got into the sea and a wave filled the car, but a bag of ballast dropped overboard sent us in a moment to a height of 900 ft.

Small free balloons, without passengers, have also been used in war for the carrying of despatches, and also to carry bombs over an enemy's position. The Austrians when besieging Venice in 1849, used the latter, but the biter was bit, for, the wind



A RECONNOITRING BALLOON. (WATCHING THE MOVEMENTS OF CAVALRY).

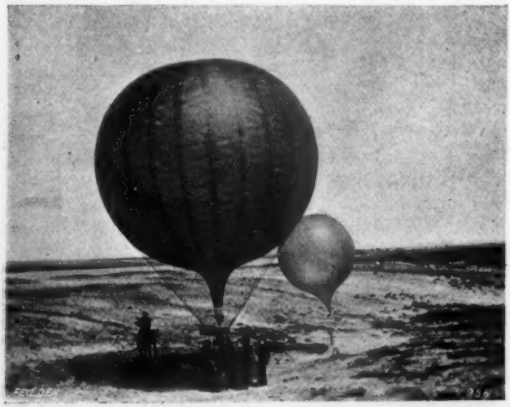
shifting, the balloons came back over the besiegers, without however doing any damage. In 1870, despatches thus carried were sent from Metz, drifted right across France to Châteauneuf, near Saint Servan, and were forwarded to Paris. So that if several balloons were sent up in a favourable wind, fitted with time fuses so as to ensure their falling in a given time, one or more would probably get through and maintain communications where all other means of communication were cut off. Balloons of this kind were also utilised in the Franklin Relief Expedition to convey to any survivors the whereabouts of our ships and the localities where provision depôts had been hidden. Small balloons of this kind were also used from Paris, and one



THE BALLOON ANCHORED FOR THE NIGHT.

with its letters intact was picked up in Surrey. In fact, during no war operations were free balloons more frequently used than that bitter winter when the conquering Germans encircled the "American's Paradise" with a wall of iron.

When Paris was invested by the Germans several practised aëronauts and four ready-made balloons were in the city. The first one despatched was a leaky machine which could not keep up long, but luckily managed to remain aloft until it had got beyond the Prussian lines. M. Godard had two balloons, neither of which was large enough to carry him from the beleaguered city, but by linking them together per-



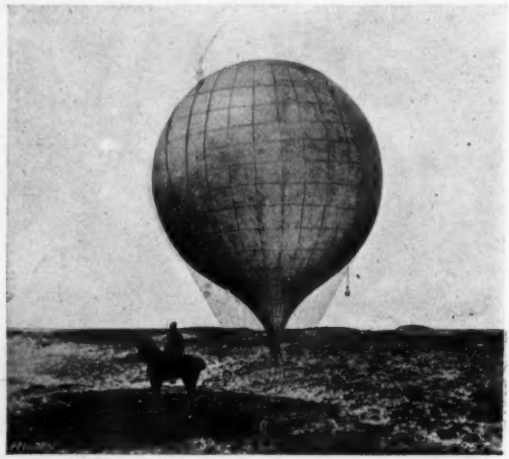
WIRELESS TELEGRAPHY: THE TRANSMITTING AND RECEIVING BALLOON.

pendicularly the two had sufficient buoyancy to enable him to make a very successful voyage in what he very aptly christened "Les États-Unis." The fourth also made a successful exit, and the Government at once ordered a number of 70,000 cubic feet balloons to be constructed, which, when filled with coal-gas, had a lifting power of some 2,000 lbs. The huge lofty railway stations then lying idle made most excellent balloon sheds and manufactories. Of the sixty-six balloons that left Paris only twelve had professional aëronauts in charge, the remainder being entrusted to the guidance of hastily and perfunctorily instructed amateurs. These were, as a rule, sailors, but some professional acrobats were also enlisted for this service. The method of training these amateurs is thus described by Colonel Templer, who quotes from M. Tissandier's history of the Paris balloons: "A car was suspended to one of the iron girders of the roof of the railway station to which the pupil climbed and then called out 'let go.' But it is needless to say that it remained stationary. He was instructed to throw out ballast and open a valve. Then he let go the anchor and went through the form of descending to earth." As Colonel Templer adds, it reminds one of taking swimming lessons on dry land. Of the balloons despatched, two, each with a sailor in charge, were carried away to sea and never more heard of. Five fell into the hands of the enemy, three near Paris and two in Germany, while one did not even get as far as the Prussian lines.

The ascents made from Paris demonstrate very clearly the great use that free balloons can be in the case of investment of a fortress, town, or camp. The principal advantages the free balloon has over the captive are firstly, that it requires much less ascensional force, as it has no weight of rope to carry. Secondly, it has no wind to withstand, for be it remembered that once a balloon is free it travels at exactly the same rate of speed as the wind. In other words, when in a free balloon, the aëronaut is practically in a dead calm, and the only sense of motion is obtained by watching the ground glide along underneath your car. You, so far as feeling is concerned, are motionless—it is the ground that is passing underneath you. Of course until the word "let go" has been given, and from the moment the grapnel takes ground, the balloon is a captive one, and the wind has its its full effect, which is the probable reason why of the relatively small number (in comparison to ascents made) of balloon accidents that have occurred, the vast majority

have taken place either at the moment of ascent or descent. In fact, in a strong wind you are safer, and infinitely more comfortable, in a free balloon than in a captive. Thirdly, and for the above reasons, a free balloon is much steadier than a captive, and observations can be made easier and more rapidly. Fourthly, even if low, a free balloon is much harder to hit than a captive, as is sufficiently shown by what has been told about the Paris balloons. Finally, with a free balloon, though the course is dependent on the direction of the wind, ascents can always be made except under very rare and abnormal conditions.

No allusion to free balloons would be complete that did not touch on the question of propulsion and steering of balloons. This, at present, has never been put to practical purposes, though it has been experimentally accomplished with a modicum of success. As far back as 1852, M. Giffard ascended from Paris in an elongated balloon, 150 ft. long by 40 ft. maximum diameter, propelled by a 3 h.-p. engine, working at 110 revolutions per minute a screw 12 ft. in diameter. He was able to get a deviation from the direct wind course, and obtained an independent velocity of five to seven miles per hour. His engine weighed 3 cwt., but had he used hydrogen in lieu of coal gas he could have taken up 3,336 lbs. weight of engine. Twenty years later M. Dupuy de Lôme, the celebrated French naval architect, made experiments in the same direction for his government, in a somewhat similar balloon with a screw propeller, and obtained a velocity of about six miles per hour. He took up, however, fourteen persons in all, whereas if he alone had ascended he would have been able to take up 1,700 lbs. weight of engine. Of late more than one Power has constructed motor and steering balloons, but they have not yet got beyond the experimental stage. Commandant Renard, of the Meudon Military Ballooning establishment, has successfully navigated a self-propelling and steering balloon from Meudon to Chatillon, thence to Versailles and back again to Meudon. The balloon is elongated, the broadest part forward, has a length of 165 ft., and greatest diameter 28½ ft. The car is 180 ft. long, very deep, and in it are carried motor power and all accessories. The motor power is electric, and an engine of 9 h.-p. gives a speed of a little over 19 miles per hour. The weight of balloon, with accessories, is 3,515 lbs., while the lifting power is 4,400 lbs.



WIRELESS TELEGRAPHY: THE RECEIVING BALLOON SHOWING THE RECEIVER.

The experimental trip was, it is true, made some years back, but later trials have been equally successful in light winds. Foreign aëronauts guard their secrets most jealously, and it is impossible to obtain recent and accurate information. In recent experiments with the sail and trail rope-gear devised by Andrée for steering—or, more correctly, in a small way influencing the direction—two trips were made, one over land and one over sea. The writer was in the car in both, and the deviation obtained from the direct wind-course, on either beam, was only 1½ degrees over land, and 3 degrees

when the trail rope was water borne. We see, therefore, that aërial navigation is still only in the experimental stage, that a free wind-guided balloon has for military purposes excessive limitations, and therefore as a practical and certain war machine the "captive" balloon holds the field up to date. Nor is its use in war a novelty, being, indeed, older than the century, for captive balloons were used by the French Army for reconnaissance purposes, and found so useful that an aëronautic school was established at Meudon in 1795. In a report to the National Convention the balloon was spoken of as "a new instrument of war which our enemies have recognised as the pioneer to victory"; and the report went on to make a prophecy, which is now fulfilled: "Soon all our armies will have complete aërostatic companies, with tents and rigging, which will be as necessary to them as parks of artillery." In 1798 Napoleon took a balloon and aëronauts to Egypt with him, but fortunately—or unfortunately, if regarded from the French point of view—one of our cruisers captured the vessel containing the hydrogen apparatus, and so his balloons were useless to him. After that for more than half a century the use of balloons for war purposes was but fitful, until they were again used by the French in the Franco-Italian campaign of 1859, and also by both sides during the American civil war. In 1862 military balloon experiments were first undertaken in England, at Aldershot, the aëronaut employed being the recently deceased veteran Mr. Coxwell, who made many captive ascents, the highest being 2,200 ft. In 1871 the English Government appointed a Committee to enquire into the use of balloons for war purposes, and in April, 1879, an official Balloon Committee was appointed and experiments and construction undertaken at Woolwich. The members of this Committee were Colonel Noble, R.E., Sir F. Able, and Captain Lee, R.E., and with them were associated Captain Elsdale, R.E., and Captain Templer, of the Middlesex Militia (now Colonel and Superintendent of the Balloon Factory at Aldershot). In 1880 the War Office detailed a whole Company of Royal Engineers (the 24th) for instruction in ballooning. Later the Balloon Factory and School of Instruction were transferred to Chatham, and finally to Aldershot, where it has now been located for some years.

In actual war operations we sent out balloons to Egypt in the campaign of 1881-2, though they arrived long after Tel-el-Kebir; but in the operations round Suakin, in 1885, they were of great service. In the Bechuanaland expedition, under Sir Charles Warren, balloons of 30,000 cubic feet of hydrogen were part of the equipment. The balloons and hydrogen cylinders were conveyed by sea to Cape Town and thence by rail and ox-wagon into the heart of Southern Africa, without leakage in a single cylinder, not a bad result considering the extremely subtle nature of hydrogen. In fact, the tubes gave out in Bechuanaland considerably more gas than was put into them at home, due, of course, to the diminished barometric pressure at 5,000 ft. above the sea-level, as compared to the normal barometric pressure at Chatham, where the tubes were loaded. To-day, balloon sections are with White in Ladysmith, with Buller on the Tugela, and with Methuen at the Modder River.

The balloons used for military purposes in the British Army are made in various sizes, 5,000, 7,000, 10,000, and 12,000 cubic feet capacity, but 10,000 is the size most generally used. An equipped section would carry three balloons of this latter size, a pilot balloon of 100 cubic feet capacity, together with cars, nets, and accessories, and an equivalent number of cylinders for the storage and transport of the gas. The material of which the balloons are made is an animal membrane used in small sizes, and prepared and soaked in a solution of glycerine and water. An enormous quantity of these pieces of membrane, running into tens of thousands, is required for the manufacture of each balloon. These are laid on in layers till a quadruple or quintuple thickness has been reached, either on boards cut to the size and shape of the gore required, or, in the case of some small balloons I have seen in process of manufacture, over the whole of an inflated

balloon itself. Over this primary layer a gut netting, somewhat similar to that in a racquet, is placed, and then over the netting several more layers of membrane are applied. The whole is then allowed to dry, and the membrane practically grows together, its constituent pieces being absolutely inseparable, except by tearing. Finally, after the whole is dried, a solution of boiled linseed oil is applied as a varnish over the entire structure. When completed, the pieces of membrane are absolutely united, while to render the structure still more homogeneous a solution of bichromate of potash is applied over the whole fabric.

The whole process has been discovered and brought to perfection by Colonel Templer, and balloons so constructed are made by no other Power. The impermeability of this material is such that the escape of gas is reduced to practically nil, and balloons are kept filled for weeks without losing any very appreciable quantity of their buoyancy. The valve consists of a steel ring, with a rubber-washer inside, against which is a light metal disc kept in its place by springs. From the underside of the disc the valve-cord falls through the balloon to the car. The valve can be opened as little as required, or to the full length of the spring, which brings it back into place immediately the valve-cord is released. And so the escape can be perfectly regulated. Unless the balloon is to be used for a free trip, the valve is moreover sealed on the inside by a piece of the material of which the balloon is made, and this, of course, can be torn away if it is necessary to empty the balloon. The valves are tested by being fitted in the neck of a cylinder, and then thrust perpendicularly down into water. If a bubble of air comes to the surface, the valve is rejected as leaky. The cylinders in which the hydrogen is stored are of specially prepared steel, and are tested to a pressure of over 4,000 lbs. to the square inch before being passed for use. They are of different sizes, but the 8 ft. long cylinder is mostly used in the field.

READY FOR WORK. (HYDROGEN CYLINDER WAGONS AND TEAMS, R.E. BALLOON SECTION.)

A cylinder 8 ft. in length, with diameter of 6 in., will weigh 95 lbs., and carry 150 ft. of gas at a pressure of nearly 2,000 lbs. to the inch. Eighty cylinders therefore would suffice to fill a 12,000 ft. cubic balloon. Hydrogen, the lightest gas known, is that used for the inflation of military balloons, though it is of course much more subtle (its rate of diffusion is about two and a half times greater) and more expensive than coal gas. Pure hydrogen is fourteen and a half times lighter than air; but when made on a large scale it is not absolutely pure, so that at a minimum the lifting power of the hydrogen used may be taken at about 70 lbs. to 1,000 cubic feet, whereas with coal gas the lifting power is only 35 lbs. per 1,000 cubic feet. The method of obtaining hydrogen is by the action of dilute sulphuric acid on iron or zinc, the latter for choice, as the gas obtained, though not so much in volume, is purer and consequently lighter. With 4 to 6 oz. of acid to 20 oz. of water, 250 lbs. of iron will produce 1,000 cubic feet of hydrogen. Steel gives off rather more gas than iron. Hydrogen can also be produced by passing steam over red-hot iron, but the process is slow and difficult, and has been abandoned for military purposes. Hydrogen can be obtained simply and rapidly by placing sodium in water, when hydrogen to the extent of 700 times the volume of the sodium is at once given off. The expense of this method is however prohibitive, as sodium is a costly metal. At Aldershot, the dilute sulphuric acid passes from its receptacle into a second one containing the granulated zinc, the sheets of which have been melted and dropped from a height into water, thus causing the metal to assume shapes on which the acid will act easily. The hydrogen thus generated then passes through a third vessel filled with water so as to purify it, and thence to the gasometer. From thence it can be passed as necessary to the room in which the steel cylinders are filled. Recently the plant at Aldershot for the manufacture of hydrogen has been considerably enlarged and improved, and for the present campaign a balloon gas-factory has been established at Cape Town.

The military balloon is, of course, much smaller than the ordinary coal gas balloon. For example, the balloon in which the writer crossed from London to near Havre a year ago, had a c.f. capacity of near 60,000 ft. as against the 12,000 ft. of the large military balloon. But, apart from the superior lifting-power of a hydrogen-filled balloon, it is necessary that it should present as small a surface as possible to the action of the wind. For this reason, long cylindrical-shaped balloons have been advocated and constructed. These have found considerable favour abroad, and we have recently constructed one of this type at Aldershot, which was prior to the war being experimented with. Although Lord Wolseley's dictum as laid down in the Soldiers' Pocket Book, "In a windy country, balloons are useless," is, perhaps, a trifle too sweeping, yet wind is the worst foe the captive balloon has to encounter. Not only is the strain on the retaining rope much greater, but also because the ascensional force must be very great to allow the balloon to rise. The balloon will, of course, drift with the wind as far to leeward of the point of retention as the length of rope will allow; and as that is a fixed point, the tendency of the wind is to drive the balloon down to earth. In this connection I may note that the rope used for tethering is a very strong but light steel hawser, having a diameter of about $\frac{1}{8}$ of an inch, or even less, and weighing about 50 lbs. to the 1,000 ft. This is run off, or on, to the drum of a windlass, which can be either stationary or fixed in the balloon cart, and the balloon thus towed to any point required. Inside the hawser is the telephone wire, through which communication is carried on with those on the ground. The advantages of a captive balloon are almost too obvious for enumeration, but some reference to them is necessary. Their value for reconnaissance is of the greatest. Not only can a large area be thoroughly observed and sketched, but it can be photographed, and a camera fitted with a telephoto lens can take pictures at a distance of very many miles.

Again, for signalling they are useful both by day and night. They can send their messages to a long distance, and

BALLOON SECTION, R.E., ALDERSHOT. (COLONEL TEMPLER IS THE TALLER OF THE TWO OFFICERS IN CENTRE OF GROUP.)

over hindering ground that would render any other method of signalling impossible. Moreover, a searchlight can be used with effect from a balloon. By Mr. Bruce's system, in which incandescent electric lights are suspended within the balloon, the latter is turned into a luminous globe. Such a balloon, fixed at the base, would be invaluable to a force making a night attack or march, for they would have behind them a fixed point discernible on the darkest night by which correct direction could be kept. At this moment, at the front, small balloons are being used to carry to the height required the installation for the purposes of Marconi wireless telegraphy. Again, the balloon runs little chance of being brought to grief by an enemy's projectiles. In the first place, it would probably be behind the first line, and out of range of rifle fire, if not of artillery; secondly, it would not be a very easy object to hit; thirdly, to get artillery to bear on it at anything of an elevation would be difficult; and lastly, even if struck, it would probably bring its occupants safely to the ground. An American balloon outside Santiago was fired at so successfully by the Spaniards, that the men in the car, an officer, an aëronaut, and the telegraph operator were all wounded. The balloon was, of course, riddled, but yet it brought the wounded occupants down in safety. The writer who tells the story, describes the balloon as riddled with shot-holes till it looked like a sieve, and yet it took 12 minutes to drop 1,500 ft. For experiment, a balloon 2,000 yards off, and 800 ft. aloft, was fired at by an 8-in. howitzer, the shell bursting in front of the balloon and tearing it badly. The balloon took 15 minutes to descend. In front of an enemy, the balloon would have been, say at 2,000 ft., and hitting it would have been doubtful. Our own new howitzer would probably be the most useful gun against a balloon, for it can be given an elevation of 70 degrees. Colonel Elsdale relates how 12 rounds of shrapnel were fired at a balloon kept moving at a horizontal distance of from 2,000 to 3,100 yards, and at an elevation

of from 1,200 to 1,500 ft., and not one shot struck. A balloon with 56 holes through it, from two rounds of shrapnel, took from 15 to 20 minutes to descend. The elevation when struck is not stated, but from the context it would appear to have been something under 1,000 ft.

Finally, a word is necessary as regards the *personnel* and equipment of a balloon section. This on a war footing comprises: 1 captain, 2 subalterns, a sergeant-major (mounted), 2 sergeants, 1 bugler, 2 corporals (mounted), 6 corporals (dismounted), 22 sappers (mounted), 16 sappers (dismounted); a total in all ranks of 53. The horse establishment comprises: 6 officers' chargers, 3 riding and 32 draught horses; a total of 41. The total of wagons and carts is eight. One wagon is for the balloons, one for the necessary technical equipment, and four for the hydrogen cylinders. These wagons are all four-horse. There are also two two-horse carts for company supply and equipment, such as baggage, provisions, forage, &c.

Much of the progress in military ballooning that has been made in this country is due to the exertions of two officers, one, Colonel H. Elsdale, R.E., now Commanding Royal Engineer at Hong Kong, and Lieutenant-Colonel Templer, the Superintendent of the Balloon Factory at Aldershot, and now on special service in South Africa. It would be hard to overestimate all that the latter has done for military ballooning in this country. He has been the moving spirit in this direction for many years, and his great practical knowledge of aëronautics and his inventive genius have been of the greatest advantage to the service and to his country. In conclusion, I would beg to express my indebtedness to papers read by the officers above named, and Major Baden-Powell, of the Scots Guards, at the Royal United Service Institution and before the Military Society at Aldershot.

H. Lawrence Hinbrune

Depreciation of Machinery.

By Professor ROBERT H. SMITH.

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The calculation of the correct charge for depreciation is quite capable of definite theoretical statement. It may be very doubtful whether in any individual case all the data needed for the theoretic calculation are ascertainable or can be estimated with a usefully close approximation. But the yearly statistics of any large engineering works ought to furnish reliable averages for such calculation for the whole machinery, bulking all kinds of machine plant together.

The depreciation of a machine in the course of any one year is clearly the change in the capitalized present value of its nett earning power, taking into account the probable duration of its remaining life. In finding its nett earning power, all the money burdens it has to carry must be brought into the reckoning.

When the machine is newly installed, its capitalized value is usually supposed to be what it has cost for purchase and installation. Subsequently it is commonly taken as this, less the sum of the yearly depreciations that have been written off. But if rationally calculated according to the above formula, the capitalized value of its earning power when new, may often be more than this initial money cost. Indeed it ought always to be so, because it ought to include some equivalent of the value of the intelligence employed in its selection and placing. A machine, well chosen for its work and skilfully placed, is, as soon as it starts work, nearly always of more real value to its owners than the money it has cost them to put it there. It would, therefore, be perfectly just at starting to *write up* the value above initial money cost were it not for the obvious fact that at the start of any new works its future prospects must be necessarily more or less problematical. But in the case of extensions of a well-established works with certainly assured prospects, nothing but recognized custom prevents such writing up of initial values being a fair and honourable proceeding.

In order to avoid ambiguity arising from this debateable point, we will not here refer to this initial money outlay as a "value" at all, but will call it simply "First Cost." It will be indicated by the letter C.

At any period of its life, the real value of a machine is its whole capital value, independently of whether it has been purchased with the owner's or with borrowed money, and independently of whether this capital value is going to be used up and destroyed as the machine becomes older, or whether it is to be preserved intact by any form of repayment sinking-fund. This real whole value may be termed the "Actual Value."

But in connection with the calculation of fair depreciation, it is simpler to think of the machine as having been bought and erected *in situ* with borrowed money, on which interest at the rate i per cent. per year is to be paid, and the principal of which is to be repaid at the end of the life of the machine. One item of yearly outlay is the payment of the interest Ci, and, if we did not approach the problem from the point of view of providing for the repayment of C, then this yearly burden Ci would continue, not only during the life of the machine, but in perpetuity after the machine had ceased to exist. The capitalised present value of its nett earning power must, therefore, be such as to provide for this repayment, that is to say, it is its actual value less the money needed for such provision, or the actual value burdened with the debt C. It is the real capitalised present value to the possessor of the machine who has borrowed the money C to possess himself of it, and who is bound to repay C. For shortness' sake, we may call this value the

TABLE I.

ANNUAL DEPRECIATION OF PRESENT INTRINSIC VALUE.

First Cost £1000. Rate of Interest 5 per cent.
Uniformly maintained Nett Revenue £100, after paying £50 Interest.

Number of Working Years still to run. $N-1$	*Ultimate Value* of Future Earnings less First Cost. U	*Present Value* of Future Earnings less First Cost, to be repaid at end. P_{N-1}	*Annual Depreciation* of Present Value during $(N-1)^{th}$ year. $P_{N-1}-P_{N-2}$
20	2574	969	56·6
19	2307	913	59·4
18	2053	853	62·4
17	1813	791	65·5
16	1584	726	68·7
15	1366	657	72·1
14	1158	585	75·7
13	960	509	79·5
12	771	429	83·5
11	592	345	87·7
10	420	258	92·1
9	258	166	96·7
8	103	70	101·5
7	− 45	− 32	106·6
6	−186	−139	111·9
5	−320	−251	117·5
4	−447	−368	123·4
3	−569	−491	129·6
2	−685	−621	136·1
1	−795	−757	142·9
0	−900	−900	

Formula :—

$$U = 2000 \times 1{\cdot}05^{N} - 3000\,; \quad P = 2100 - \frac{3000}{1{\cdot}05^{N-1}}\,; \quad P_{N-1} - P_{N-2} = \frac{150}{1{\cdot}05^{N-1}}$$

"Present Value," and it will here be represented by the symbol *P*.

This "present value" is that of the balances of all the *future* incomings over outgoings. It is a sum of money which, if invested at *present*, will *eventually* yield the same result as will the similar investment of all *future* annual balances of income over expenditure, these latter being burdened with the eventual repayment of *C*. The date at which the account is *eventually* made up and closed is naturally when the machine is used up and done with, that is the end of its "life." This "present" value has only to do with the future, it leaves out of account all the results of the work already done by the machine. The past earnings already won by the machine may have been more than sufficient to pay off its first cost; but as the repayment of this is postponed to the end of its life, this repayment of *C* is reckoned as one of the future items of expenditure on behalf of the machine. The proper charge for *depreciation* does not in the least depend upon whether the repayment of *C* is really made at the beginning or at any period of the life, or is postponed to the end of the life. In any case, the calculation of the deprecia-

tion for any particular year, if properly made, will come out the same. The calculation is simply made easier by considering this repayment postponed to the final settlement of the account of all the earnings of the machine. Taking it so, it is clear that near the end of this life, the "present" value as above defined must become negative; the few remaining nett earnings invested and accumulated to the end cannot of themselves suffice to pay off the debt C on the machine. In fact, at the very end we have in the "present value" only the nett earnings of the last year as a set-off against the debt C. Thus for several years, it may be, before the end the continued possession of the machine represents only a balance of debt; no one would take over the machine from its possessor with the liability to pay this debt C without being paid for so taking it over. Of course, this is no reason for discontinuing the working of the machine; its earnings during its last few years help to furnish funds wherewith to pay this debt, which would be a more onerous obligation without such help. In Tables I. and II. and in diagrams A and B below may be seen how the "present" value decreases,

TABLE II.

ANNUAL DEPRECIATION OF PRESENT INTRINSIC VALUE.

First Cost £1000. Rate of Interest 5 per cent.

Nett Revenue after paying £50 Interest on First Cost, £100 during the 21st year from end of life, and decreasing by £2 per year to £60 during the last year.

Number of Working Years still to run. $N-1$	*Nett Revenue* Average of N years from end. $R-W$	*Ultimate Value* of Future Earnings less First Cost. U	*Present Value* of Future Earnings less First Cost, to be repaid at end. P	*Annual Depreciation* of Present Value during $(N-1)^{th}$ year. $P_{N-1}-P_{N-2}$
20	80	1858	700	62
19	79	1612	638	64
18	78	1382	574	66
17	77	1166	509	68
16	76	964	441	69
15	75	774	372	71
14	74	596	301	73
13	73	431	228	75
12	72	275	153	77
11	71	130	76	79
10	70	− 6	− 3	81
9	69	− 132	− 84	83
8	68	− 250	− 167	86
7	67	− 360	− 253	89
6	66	− 463	− 342	92
5	65	− 558	− 434	95
4	64	− 646	− 529	98
3	63	− 729	− 627	101
2	62	− 805	− 728	104
1	61	− 876	− 832	108
0	60	− 940	− 940	

and changes from positive to negative. In the early years of the life, it represents a large positive value over and above what is needed for the future repayment of C. In the later years the possessor would be only too glad to get rid of the machine if he could also at the same time free him self of the obligation to repay the debt C; but he cannot do so, and is therefore glad to continue to use the machine to help him to discharge this obligation. This

DIAGRAM A.

ANNUAL DEPRECIATION OF PRESENT INTRINSIC VALUE.

First Cost, £1000. Rate of Interest 5 per cent.
Nett Revenue after deducting Interest on First Cost £100, maintained uniform throughout term of 21 years.

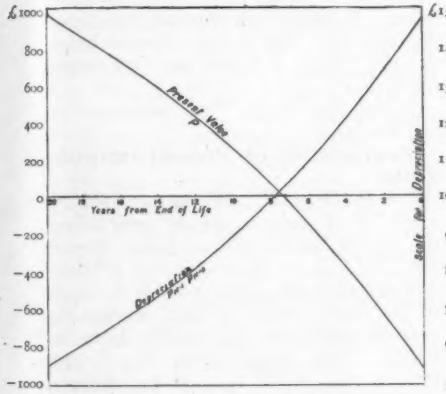
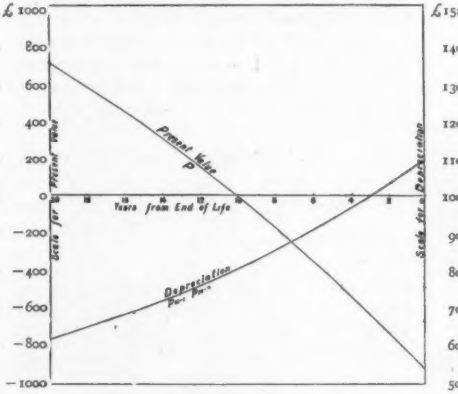


DIAGRAM B.

ANNUAL DEPRECIATION OF PRESENT INTRINSIC VALUE.

First Cost, £1000. Rate of Interest 5 per cent.
Nett Revenue after paying £50 Interest on First Cost, £100 during 21st year from end of life and decreasing by £2 per year to £60 during the last year.



explanation seems necessary in order to explain what may at first sight appear to be paradoxical in speaking of a negative present value. The seeming paradox only results from this being the easiest way in which to reason with clearness and accuracy regarding the real depreciation of value.

If a sum equal to the present value P were invested, and were left to accumulate at compound interest at the rate i per cent. until the end of the life, and if there be still $(N-1)$ years of the life to run, then at the end of this period, it would have accumulated to the amount $P(1+i)^{N-1}$. This holds good whether P be positive or negative.

In order to explain the calculation, we must refer to another value which might be called the "deferred value," but which engineers will probably understand more clearly if it be called the "Ultimate Value." This, at any period of the life of the machine, is the estimate of what the accrued value of all its future nett earnings will amount to at the end of its life after repayment of the debt C. Let the *gross* money earning power per year be called R, and let the estimated remaining years of life be N in number. In the first of these years, let this gross revenue be R_1; in the second R_2, *et cetera*; in the last let it be R_N.

Against this gross revenue are to be charged several items of expenditure before we arrive at the nett earning power. Firstly there is Ci, the interest on First Cost. Then there are the annual wages of the artisans in charge; the annual cost of driving power; the annual cost of maintenance (including oil, tools, &c.) and repair; a fair proportion of general shop charges, and rent, rates and taxes; and a tax to cover general management and office expenses. If the gross

revenue R is taken as the total value of the products as turned out by the machine, there must also be charged against it the cost of material as supplied to the machine to be worked up. Let the sum of all these charges, including Ci, be called "Working Costs," and symbolised by the letter W; W_1 in the first of the term of N years, W_2 in the second, W_N in the last.

Thus the nett annual earning power, or nett revenue, is $(R - W)$: that is, $(R_1 - W_1)$ in the first year, $(R_2 - W_2)$ in the second and so on until the last year of life, when it is $(R_N - W_N)$.

If we suppose each of these annual nett revenues invested as it arises at i per cent. interest; reckon what each will accumulate to at compound interest at the end of the N years; add all these sums together and deduct from the amount the repayment of debt C; this calculation will give what we have defined as the "Ultimate Value." Call this U.

Thus the Ultimate Value will be at end of first year

$$(R_1 - W_1)(1+i)^{N-1} + (R_2 - W_2)(1+i)^{N-2} + \ldots + (R_N - W_N) - C = U_1,$$

and at end of second year

$$(R_2 - W_2)(1+i)^{N-2} + \ldots + (R_N - W_N) - C = U_2$$

there being in the first series one more term than in the second, and the same values in corresponding terms in both, *provided that* during the second year nothing has occurred to alter the fair estimate of the probable life of the machine, or of its future earning powers, or of its future working costs.

It is here advisable to distinguish between *intrinsic* and *extrinsic* values. The former changes only in consequence of change in the machine itself. The latter changes also in consequence of change in external circumstances, such as selling price of the articles produced, prevailing interest obtainable from investments, first cost, efficiency and economy of new patterns of similar competing machines brought into the market. If there be considered only change of intrinsic value, and if there have been no damaging breakdowns, or other accidents, then term by term we have the same values of W, R and N in the above two series. Their difference is, therefore, the first term of the first series. That is, decrease of Ultimate Intrinsic Value during the $(N-1)^{th}$ year before the end of the machine's life

$$U_1 - U_2 = (R_1 - W_1)(1+i)^{N-1}.$$

Now if P_1 and P_2 be the Present Values at the ends of the first and second years of the N remaining years of life, the Ultimate Values corresponding to these would be $P_1(1+i)^{N-1}$ and $P_2(1+i)^{N-2}$. $P_1(1+i)^{N-1}$ is to equal the sum of the terms of the first of the above two series (including the last term—C), and from this equality P_1 can be calculated if desired. Similarly $P_2(1+i)^{N-2}$ equals the sum of the second series. The difference between these, or $\{P_1(1+i) - P_2\}(1+i)^{N-2}$ must equal the decrease of ultimate intrinsic value. Forming this equation and dividing each side of it by the common factor $(1+i)^{N-2}$, there is found the very simple result:—

During the $(N-1)^{th}$ year before end of machine's life

Depreciation of Present Intrinsic Value

$$= P_1 - P_2 = (R_1 - W_1)(1+i) - P_1 i$$

where R_1 W_1 refer to the N^{th} year before the end of the life, and P_1 is the Present Intrinsic Value at the end of that N^{th} year. The first term $(R_1 - W_1)(1+i)$ is the result of last year's profit invested during the year in which the depreciation is to be found. The second term $P_1 i$ is the interest that would be paid for this one year on the last year's estimate of value.

Note that although this very simple formula is apparently independent both of C and of the estimated future values of R and W, it is only *apparently* so because P_1 involves all of these. Also, of course, the earning power R_1 and working costs W_1 are both of them large or small in correspondence with first cost C.

It may also be well to explain this formula in respect of two rather obvious criticisms. Firstly, it may be objected that if the nett revenue $(R_1 - W_1)$ in the previous year were zero, then the formula would make the depreciation negative, *i.e.*, a *rise* of value of a machine giving no useful result. But if the machine give no nett revenue it is valueless, and there arises no question at all of depreciation.

And, in fact, by looking at the first series U_1 ending in $-C$, which is equal to $P_1(1+i)^{N-1}$, it is seen at once that in case of all the $(R-W)$'s being zero, the value of P_1 is negative, and therefore the depreciation $-P_1 i$ is positive. It is, in this case, exactly $+\frac{Ci}{(1+i)^{N-1}}$ and represents the increase of the sum that would need to be set apart to accumulate at compound interest in order to pay interest on and extinguish the debt C at the time its repayment becomes due.

Secondly, it might be said that if $(R_1 - W_1) = P_1 \frac{i}{1+i}$ then the depreciation thus calculated will be zero. $P\frac{i}{1+i}$ is a little less than Pi, the interest on the present value, and if the nett earning power does not equal considerably more than this, clearly the machine is of no real value at all. This case is quite similar to the last. A machine that is not paying its way and is loaded with the debt of its first cost, is the negative of an advantage to its possessor, and "depreciation" has its meaning reversed; it means that the possession of the machine becomes more costly year by year as the time approaches at which the debt C has to be repaid.

In the form given above for the intrinsic depreciation no assumption is made as regards the manner in which the gross revenue and the working costs of the plant may be estimated to vary from year to year during the remaining N years of life. These may remain constant, or the one may increase and the other decrease, or any sort of irregular variation in each of R and W separately may be assumed in the estimate: the formula still remains correct so long as these estimated values remain the same at the end as at the beginning of the year in question.

If, however, in the series of N years involved in the calculation of U the values of R and W be assumed uniform; or, if, knowing that they will not actually remain uniform, we still say that in view of our not being able to predict with any exactitude how they will vary, it is not worth while to complicate matters by reckoning from anything more precise than what is believed will be fair *average* values of R and W; then the results appear in a form involving much less calculation. For the series U then becomes an ordinary geometrical progression, the sum of whose terms is given by a well-known formula. The result is, remembering that the "Present Value" invested at i per cent. compound interest accumulates in $(N-1)$ years to the same as the "Ultimate Value," Ultimate Value U_1

$$= (R-W)\frac{(1+i)^N - 1}{i} - C = P_1(1+i)^{N-1}$$

Therefore $P_1 i = \frac{(R-W)\{(1+i)^N - 1\} - Ci}{(1+i)^{N-1}}$

giving $P_1 = (R-W)\left(\frac{1}{i}+1\right) - \frac{R-W+Ci}{i(1+i)^{N-1}}$

at end of N^{th} year, and therefore depreciation of Present Intrinsic Value $= P_1 - P_2$ during the $(N-1)^{th}$ year

$$= (R-W)(1+i) - P_1 i = \frac{R-W+Ci}{(1+i)^{N-1}}$$

To avoid error by confusion, it may be well to point out that W, the working costs contains the item Ci, so that in the quantity $\{R-W+Ci\}$ the interest on prime cost, viz., Ci cancels out. Thus, if W^1 means the working costs *exclusive* of interest on first cost, then

Depreciation of Present Intrinsic Value during the $(N-1)^{th}$ year before end of life.

$$= \frac{R - W^1}{(1+i)^{N-1}}$$

Nett annual Revenue *without* deducting interest on First Cost.

This very simple result might possibly have been demonstrated more directly if there had been assumed from the first an unvarying revenue and unvarying working costs. But the method adopted here is best suited to explain the alteration made in the result by the operation of circumstances external to the machine itself. This modification should now be recognised easily. Because the depreciation in any one year is always the change in the "Present Value" from the beginning to the end of that year, no matter what have been the causes that

have changed that value. Some of these causes are intrinsic and some extrinsic. For instance, the actual first cost C is a *fait accompli* that cannot be affected by any change in external circumstances, but the annual charge Ci for interest on that first cost may vary, because, although there is a fixed rate of interest attached to debentures and other borrowed money, still these may be converted if such changes occur in the money market as to make the conditions of the debentures oppressively onerous. Again, the quantity of goods produced by the machine per year may increase in virtue of there being introduced new and better methods of handling it, or new and better tools for it; and again, the market price at which these goods can be sold may vary largely, independently of any change in the machine itself. Again, the rate of wages paid for the labour of working the machine, and the cost of fuel and other items going to the cost of driving-power, may change in either direction. Thus, both R and W are liable to change from a variety of causes quite irrespective of any decay of the intrinsic working capacity of the machine.

Now at the end of the first year the "Present Value" P_1 is to be calculated by putting $P_1(1+i)^{N-1} = U_1$; and at the end of the second year, the then "Present Value" P_2 is to be similarly calculated by putting $P_2(1+i)^{N-2} = U_2$. The value of U_1 is found by help of the series, already stated, with the proper values of R and W inserted as estimated from all the conditions, intrinsic and extrinsic, known at the end of the first year. The value of U_2 is similarly calculated with the insertion of the proper values of R and W, as re-estimated from the altered conditions at the end of the second year. Then the depreciation during this second year is simply $P_1 - P_2$.

If the calculations of U_1 and U_2 be each made from average estimated values of R and W, the first U_1 from the averages estimated at end of first year as likely to fairly represent the N years, and the second U_2 from averages re-estimated at end of second year as likely to fairly represent the $(N-1)$ years, then the geometrical progression formula may be used with greatly simplified results. Let the first estimated averages be called R_1 and W_1, while the second estimated averages are R_2 and W_2; then it is not difficult to demonstrate that the result is as follows :—

Depreciation of Present Extrinsic Value $= P_1 - P_2$

$$= \frac{\left\{(R_1 - W_1) - (R_2 - W_2)\right\}\dfrac{(1+i)^N - (1+i)}{i} + \{R_1 - W_1 + Ci\}}{(1+i)^{N-1}}$$

this being for the $(N-1)^{th}$ year from the end of the life of the machine. The only assumption made in deriving this formula is that i, the rate of interest affecting the problem, has not changed. It is useful to compare this with the formula given above for the purely intrinsic depreciation, and to recognise that it reduces to the same amount in case $(R_1 - W_1) = (R_2 - W_2)$, that is, if the estimates of average nett revenue be the same at the ends of the two successive years. The last term is the strictly intrinsic depreciation, while the first is the excess of the whole over this due to extrinsic change of conditions Table III. gives the value of the factor in this first term. The Table strikingly illustrates how much more damaging is an adverse change of external conditions in the early life of a machine when most of its earning work lies in the future than is the same change occurring at a later date when its utility has been nearly used up.

This fully covers the case of "antiquation" of pattern due to the introduction upon the market of new and improved machines. These new machines may have advantages in competition with the old machine of four different kinds :— (1) the first cost of purchase and installation for same quantity of production per annum may be lowered; (2) the quality of the produce may be raised so as to command in the market a better price

for the same quantity; (3) the wages needed to be paid to artisans may be lowered; (4) the space occupied in the works and the driving power needed may be diminished. No. 2 gives the new machine a greater gross revenue than the old one, while Nos. 1, 3 and 4 make its working costs lower.

Thus the nett revenue from the new machine is greater, and this enables its possessor to sell at a lower price than the possessor of the old machine got before his competitor appeared. If the owners of the new plant do actually sell at the lower price, then the owner of the old plant must also do so, and this makes his R_2 less than his R_1 of the previous year. If the owners of new plant do not actually bring down the market price, then they may make their fortunes more quickly than those owning the old plant, but they do not diminish the utility of the old machine to its possessor and do not depreciate the value of his machine. The fact that others have more profitable machines does not make his less valuable except in so far as it actually diminishes its nett earning capacity. Without any diminution of market selling price of the produce the old machine's earning capacity may be reduced to zero in two ways: firstly, the better quality of the product of the new machine may make that of the old one unsaleable; and, secondly, the superior profits yielded by the new one may be spent in such greater liberality on advertising and other "business pushing" as to beat the products of the old one out of the market. In either case the old machine ceases to work for the whole or part of the year, and its gross revenue becomes zero, or is proportionately reduced. In whatever way the introduction of improved plant operates it takes effect in reducing the R of the old machine, thus making R_2 less than R_1, and the effect of this on the proper and fair depreciation is completely covered by the formula last given.

In another place the writer has suggested that the problem of depreciation by antiquation of design might be solved by a comparison with the cost —capitalised cost taking account both of prime cost and working costs—at which the old machine could be replaced by a new machine capable of doing the same quantity and quality of work. But it appears difficult to make this comparison a fair one on account of the substituted machine being usually necessarily a new one, with presumably a longer life than that of the displaced machine. No rational comparison can be made of their values without taking into account the respective probable working lives of the two.

Two examples are here given in Tables I. and II., illustrated by Diagrams *A* and *B*. In each of these the rate of interest is assumed as 5 per cent. and the First Cost £1,000, so that the charge against the machine for interest is £50. In each example the calculations are extended back to the depreciation during the 21st year before the end of the working life, this coming into the account 20 years before that end. In both cases change of intrinsic value alone is reckoned. In each case the *nett* revenue, without deducting interest on First Cost, is supposed to be £150 during this 21st year, this leaving £100 nett receipts after payment of interest. In Table I. and Diagram *A*, this is supposed to remain steadily at £100 during the whole term of 21 years. In Table II. and Diagram *B* it is supposed to diminish regularly from £150 to £110 in the last year, or from £100 to £60 after payment of interest. At the start, therefore, the *average* to be used in the calculations is £130 and £80 before and after deducting interest, and this average decreases uniformly to £110 and £60 in the last year.

Turning to the first case of uniformly maintained nett revenue, Table I. shows in the second column that when the machine has still 20 years to work, its future earnings will, if invested at 5 per cent., accumulate at the end of the 20 years to £2,574 *over and above* the £1,000 to be repaid at that date, this also providing for payment of the £50 interest on this £1,000 throughout the 20 years. When there are still 13 working years to run, the earnings still to be made will give at the finish £960 over and above the £1,000 to be repaid. When the remaining working life is

reduced to $7\frac{1}{3}$ years, the ultimate value is reduced to zero; that is, beyond this time the future earnings are just sufficient for the payment of interest and final repayment of principal of the first-cost debt. At the end this ultimate value is £900 debt, which means that at this date there is simply the one year's income of £100 to set off against the debt of £1,000. The third column gives the same results in the form of "present value." Twenty years before the end the investment of £969 would give ultimately the same as the actual results; 13 years before the end £509 invested would do the same; $7\frac{1}{3}$ years before the end the "present value" is zero, because the future of the machine just pays its own way and its own debt and no more; while at the finish the present value is the same as the ultimate value, namely, £900 debt. The last column gives the depreciation, or yearly lessening of present value. It begins with £56 12s. during the 20th year from the end, and increases gradually at first by about £3 per year, and towards the end by about £6 per year; so that it is about £100 per year when the present value changes from the nature of an asset to that of a liability, and becomes £142 18s. during the last year of life.

In Diagram *A* are plotted out the two curves of decreasing "present value" and of slowly increasing intrinsic depreciation. The vertical scale to which the latter is plotted is twenty times more open than that of the former, and is figured on the right hand edge of the diagram. The years of life are plotted horizontally. The "present value" diagram curves downwards, while the depreciation diagram curves upwards.

In Table II. both ultimate and present values are naturally less than in Table I. so long as they represent a positive asset; but also, for the same reason, namely, the smaller and decreasing scale of earnings, during the last few years they represent heavier liabilities than in Table I. The present value starts at £700 instead of £969 as in the previous case; it changes its sign earlier, namely, ten years before the end, and finishes as a debt of £940 in place of £900. This £940 is the debt £1,000 less the £60 nett revenue to the last year of life. Owing to the decrease of earning power the depreciation is at first greater than in Table I., being £62 per year at twenty years before the end of life, and increasing at first by £2 per year and later on by £3 per year. When there are still fifteen and a half years of future working life the yearly depreciation is the same in the two tables, and after this date that in Table II. is less than the other. It finishes at the amount of £108 per year.

Diagram *B*, drawn to same scales as *A*, shows the two curves of present value and depreciation, each of less vertical range than its analogue in Diagram *A*. The curve of depreciation is very flat, and may without material error be taken as a straight line.

It must be borne in mind that these examples show only intrinsic depreciation, unaffected by change of external circumstances, such as lowering of market price or introduction of improved types of competing machinery.

Decidedly the most striking feature of these calculations is the manner in which they make the yearly depreciation *increase* as the years pass and the end approaches. It is hardly necessary to say that the most prevalent notion of the fair charge for depreciation is that it should *decrease*. The writer believes that this notion is based upon the idea of a *constant percentage* of the *remaining value*, and as the remaining value of course decreases, so also does the depreciation. But it must be noted that the opinions among men who have thought carefully on the subject are very diverse. For instance, some of these maintain that a larger percentage of first cost ought to be written off during the first two or three years; but this seems, although an error so to speak in the right direction of prudence and honesty, to be still an error arising from consideration of the *selling value* instead of the *working value*. If a joint stock company has been promoted and formed for the pure purpose of dissolving in the bankruptcy courts in a few months or a few years, then, no doubt, the honest depreciation of plant would be calculated

from selling values; but in such cases, not much attention of any kind is paid to this subject. In *bonâ fide* concerns, however, it seems clear that the selling value of the plant is altogether the wrong basis from which to reckon. Then others hold that during the first year there is no depreciation, and in the second and third, very little, because the plant has not got fairly to work until some time after installation, and because, if it be originally of good quality, there are few or no repairs needed, that is, there is little or no real damage done to it—it remains "as good as new." And again, the writer has come across men who, although they have never made a single attempt at calculation on the subject, still have lived among and in charge of machines all their lives, who have imbibed a fellow-feeling for, and an intuitive capacity to "understand" machines, and who say that the real value of a machine varies very little for a long time, and then comes "crashing down" towards the end.

This paper is an attempt to put upon a scientific basis the feelings of this last set of friends of machinery. The answer to all the arguments referred to above is simply this, that it is not depreciation of the "first cost" at all that is here calculated. The author has tried but has failed to attach any intelligible meaning to the phrase "depreciation" as applied to first cost, and he therefore thinks it futile to attempt any scientific reckoning of depreciation as a percentage of first cost. Of course, first cost is an important factor in the problem; but the real essential dominating fact to deal with is *working value*, that is, the value which is, or is to be, the outcome of the use of the machine during its whole life. If the machine were entered in the accounts as an asset at a money value equal to first money cost, then it must be admitted that the depreciation put down in these tables could not be rationally deducted from this asset so valued; but on the other hand, no other fair depreciation could be rationally calculated so far as the present writer can see. As explained at the beginning of this article, however, this first money outlay by no means represents the real value to the possessor. At the head of Table I. the "present value" is £969, and this value is clear of all debt, that is, although the possessor has not himself furnished the £1,000 of first cost, the £969 is the value over and above the full provision for interest and principal of the debt when due. If this latter provision were capitalised and added to the £969, it is easy to show that the amount would be £2,020, or more than double the £1,000. If there be no debt to set off against the possession of the machine, then it is at this date an asset of the real value of £2,020. That is, its real present value has been appreciated by £1,020 by the fact of its having been intelligently selected and placed so that it gives a prospect, upon a reasonable and prudent estimate, of clearing £150 nett profit per year for 20 years, or £3,000 nett profit in all. It is upon this asset of £2,020 that the fair depreciation in the following year is £56 12*s*. Both the money value of the asset and the depreciation are in a certain sense speculative; they both depend upon an estimate of future profits and of future durability; but it cannot be too distinctly understood that all estimates of depreciation, on whatever principle they are based, must in their very essence be necessarily speculative in the same sense.

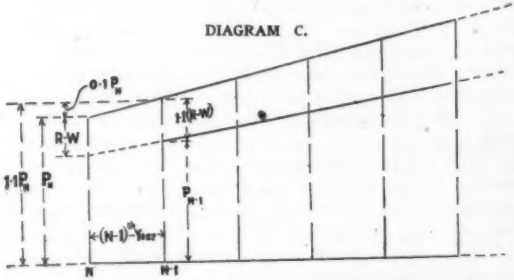
The difference between £969 and £2,020 depends upon whether the machine is burdened with the debt of its first cost, or whether it is free of debt. It is easy to show that the fairly calculated depreciation is precisely the same in either case. We will not further lengthen this article by giving the mathematical demonstration of this equality, but will ask our readers to accept the statement that it has been strictly demonstrated that the fair depreciation is the same whether or not the machine is burdened with debt (equal to its money first cost) or is an asset free of liability.

Accepting these views, the quickest way to recognise that the depreciation (of *intrinsic* value) must *increase* from year to year is to refer to our first expression for it, namely, $(R-W)(1+i)-Pi$. So long as $(R-W)$ does not vary much, this must

increase because P decreases, so that less and less is subtracted from year to year.

This simple formula may perhaps be most plainly demonstrated and its meaning most clearly elucidated by the graphic proof of it given in Diagram *C*. Here in order to make the differences of height more readable, there is assumed 10 per cent. interest. The horizontal scale represents years, and the diagram starts at a date marked N, which means the end of the N^{th} year from the death of the machine. Here there is plotted upwards the already ascertained value of the "present value" at the end of this N^{th} year. It is marked P_N. This is a sum of money which, if laid out at compound interest, would mount up year by year as shewn by the height of the upper

DIAGRAM C.



curve, each ordinate of which is higher than the preceding one in the ratio $\frac{110}{100}$; and which would finally at the death of the machine accumulate to what we have termed the "ultimate value" of the N years' earnings. Thus at the date $N-1$, its height is $1{\cdot}1\ P_N$, and it has risen $0{\cdot}1\ P_N$ during the $(N-1)^{th}$ year from the end.

At the date $N-1$ there is plotted upwards the new "present value," marked P_{N-1}, and there is also drawn the curve showing how it would, if invested, accumulate to the new "ultimate value," which is less than the previous ultimate value of date N, inasmuch as it is the accumulated value of only $N-1$ years' instead of N years' earnings. The difference is due to the omission in the second series of the earnings of the N^{th} year. The lower curve mounts step by step in the ratio $\frac{110}{100}$ in exactly the same manner as the upper one, and the difference of their heights therefore also increases by the same law. This difference of height is simply the nett revenue of the N^{th} year accumulating separately at the same compound interest. Therefore if the lower curve be produced backwards to date N, it would cut off from the top of P_N, a height equal to this N^{th} year's revenue, which is marked $R-W$ on the diagram. Thus at date $(N-1)$ this difference of height of the two curves is $1{\cdot}1\ (R-W)$. A glance at the diagram will now show that the height P_N is greater than the height P_{N-1} by $1{\cdot}1\ (R-W)-0{\cdot}1\ P_N$. This is the result to be demonstrated, or in other words

Depreciation of Present Intrinsic Value during the $(N-1)^{th}$ year

$$P_N-P_{N-1}=(R-W)(1+i)-P_N i.$$

In conclusion, there ought to be considered the chances of the acceptance of this method as a practical basis of calculation in actual accountants' work. No objection whatever can be raised to it on the score of want of simplicity. Nothing could be simpler and easier of application than the depreciation formula given.

The first real objection that will be raised is, that the total of all the depreciations written off sums up to more than the initial outlay. This will be so when the "present value" at the beginning of the life is more than the capital money outlay—as it ought *always* to be. There are two practical influences, one against and the other for agreement to this initial appreciation of value. Firstly, the ratepayer on machinery does not wish his plant to be rated higher than he can help, and his impulse is to object to a rating higher than the initial outlay. The rating is, however, on the earnings and not on the capital value. The appreciation of capital value might or might not influence the estimate of earning value. It might quite possibly lower this latter estimate; because if the appreciated capital value be recognised as real value, it can be sold for a price representing this real appreciated value, and the purchaser

would then fairly charge against his plant the greater amount of yearly interest payable on the purchase money. And, again, from this ratepayer's point of view, it is to be remembered that although the initial present value is raised in accordance with this theory, it falls from year to year more rapidly than according to any usual mode of reckoning depreciation. It is risky, especially at the present time, to argue in favour of such initial appreciation of present value from the *promoter's* point of view. It may be admitted that the promoter may be only too ready to over-estimate this appreciation. But it may be suggested that such initial appreciation of "properties" is, as a matter of fact, very largely adopted and permitted; for example, consider the values placed upon newly-built houses as compared with their actual money cost. It must be admitted also that the extravagancies of the company-promoter will not be so easily abolished by the expected House of Lords Bill, as the authors of that Bill very justly hope. The very fact that the public allow themselves to be beguiled to their ruin by the company-promoter perhaps proves that they operate from a basis which has fundamentally an element of truth in it. If such appreciation of value does actually exist in any measure, even a small one, as a solid reality, would not the better way of scotching the promotion-evil be to frankly admit the reality of the appreciated value, and to concentrate our efforts upon finding effective means to rigidly prohibit its over-estimation beyond honest and rational limits?

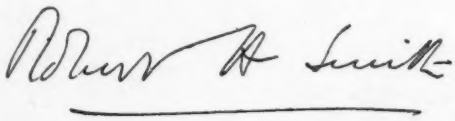
There is also the point that this formula makes the depreciation per year grow larger as years pass by. This is not in accordance with most common practice in industrial account keeping, and few, in any case, would at first sight agree to so rapid a yearly increase of depreciation as is shown in Tables I. and II. But it will hardly be contradicted that there is a wide-spread feeling that the common practice of writing off each year a constant percentage of the original outlay errs in respect of being too hard upon the early life of a machine, and that the real earning value shrinks in a rapidly increasing manner towards the end of its life.

TABLE III.

Value of Factor for Extrinsic Depreciation. Rate of Interest 5 per cent.

$$\frac{(1+i)^N-(1+i)}{i\,(1+i)^{N-1}} = \frac{1}{i}\left\{(1+i)-\frac{1}{(1+i)^{N-2}}\right\} = 21-\frac{20}{1{\cdot}05^{N-2}}$$

N	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
Factor	13·46	13·08	12·69	12·27	11·84	11·38	10·90	10·40	9·86	9·30	8·72	8·10	7·46	6·78	6·08	5·33	4·54	3·72	2·86	1·95	1



The portrait and biography of Professor ROBERT H SMITH appeared in the October, 1899, issue of this Magazine, under an article which dealt with "Governors; or, Control and Steadiness in Machinery."

Modern Appliances in Gas Manufacture.

By FLETCHER W. STEVENSON, M.I.C.E.

(Continued from page 167.)

IT is with much pleasure that we are enabled to present this month a portrait of the author of these articles. MR. FLETCHER W. STEVENSON, fifth son of the late G. W. Stevenson, of Parliament Street, Westminster, was born at Notting Hill in 1854. He received his technical education in his father's office, and afterwards assisted him in the design and construction of various gas and water undertakings. For ten years he was engineer and manager of the Chester United Gas Company. From 1888 to 1899 he was chief engineer to the Sheffield United Gas Company, and is now in consulting practice in Westminster. He is a member of the Institution of Civil Engineers, and member of the Institution of Gas Engineers and also the Gas Institute.

THE purification of coal gas may be said to commence from the moment that its temperature begins to fall after leaving the hot retorts in which coal is distilled; but this is almost entirely mechanical, and chiefly consists of the deposition of liquids whose vapour tension is too low to remain in a gaseous form at any but comparatively high temperatures. These liquids are sharply defined into tar and water, the latter being strongly impregnated with ammonia and technically called ammoniacal liquor.

The principal impurities left in the gas after condensation are tar, ammonia, carbonic acid, sulphuretted hydrogen, and bisulphide of carbon. The whole of the tar and ammonia, and part of the carbonic acid and sulphuretted hydrogen, can be taken out by washing and scrubbing, and the remainder must be removed by lime and oxide of iron.

WASHERS AND SCRUBBERS.

The Livesey washer (Fig. 42) is one almost universally used for removal of the tar. It consists of a rectangular box made of cast-iron plates. About 12 inches from either side is a drop plate connected to the top of the washer, descending 12 inches from the top and running its whole length. These drop plates divide the upper half, or gas space, into three compartments—the wide central one being the inlet, and the two narrow side chambers the outlets. Flanges are provided on the lower edge of the drop plates, and to these are bolted inverted U tubes of sheet iron rather more than the length of the central compartment (Fig. 43). Into the U tubes are secured other bent tubes of sheet iron, but closely perforated with holes $\frac{1}{16}$ in. diameter, the ends of these and spaces between them at the ends being stopped with wood blocks or Portland cement.

The washer being filled with ammoniacal liquor nearly to the top of the bent perforated tubes, gas enters the central compartment, but the drop plates preventing it passing direct into the side chambers, it is forced down between the inverted U tubes and through the perforations in the inner tubes which are covered with liquor, and rises above these into the

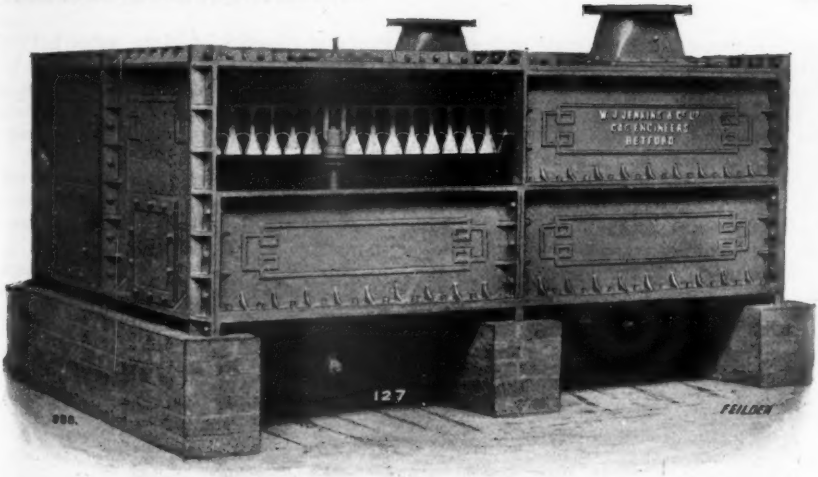


FIG. 42.—THE LIVESEY WASHER, WITH SIDE PLATE REMOVED TO SHOW END OF TUBES.

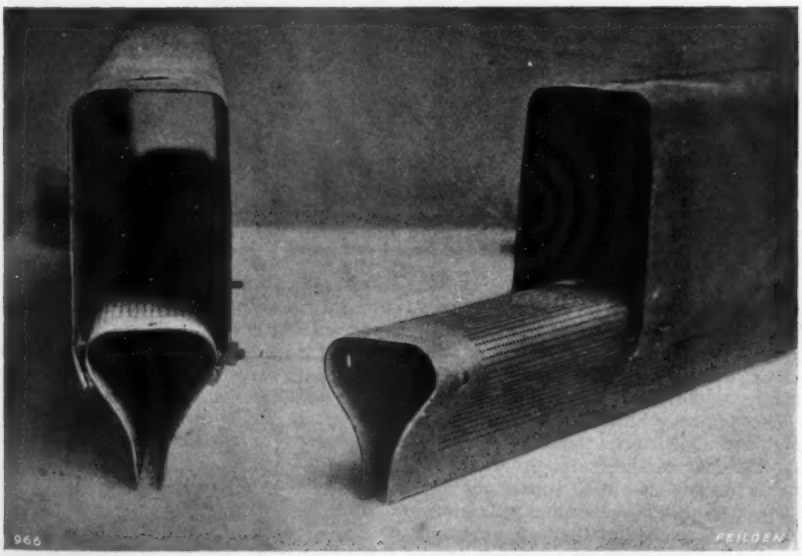


FIG. 43.—INVERTED U TUBES AND PERFORATED TUBES FOR LIVESEY WASHER.

space between the perforated and plain tubes and so into the side gas chambers, from which the outlets are taken.

While the gas is being forced through the perforated tubes considerable ebullition takes place in the liquid, and this, together with splitting the gas into such fine streams to pass through the perforations, effectually breaks up the bubbles of tar mechanically carried forward, and removes practically every trace of tar from the gas.

It is a moot point with engineers as to the form of scrubber to be used after a tar extractor such as the Livesey washer; some pinning their faith entirely to the Tower scrubber, while others do so equally to the rotary washer scrubber.

The author ventures to think that a combination will give the best results—that is, after passing through a tar extractor the gas should be passed through a Tower scrubber and washed with strong ammoniacal liquor and afterwards through a rotary washer scrubber in which clean water is used to effect final removal of ammonia. In this way he believes that the least quantity of clean water (which is injurious to the illuminating power of gas) can be used, and the best results obtained in extracting other impurities and saving the work done in the purifiers themselves.

This plan has been adopted in the Grimesthorpe station of the Sheffield Gas Company, the whole of the ammonia shown by the litmus paper test being removed by the use of about 0·33 gallon of water per 1,000 cub. ft. of gas, and an average of tests made showing the removal of other impurities to be as follows:—

FIG. 44.—WASHERS AND SCRUBBERS AT THE GRIMESTHORPE STATION OF THE SHEFFIELD GAS COMPANY.

	Grains per 100 cub. ft. of gas.		
	Inlet of scrubbers.	Outlet of scrubbers.	Absorbed by scrubbers.
Carbonic acid ...	1336	848	655
Sulphuretted hydrogen ...	765	655	113

The Tower scrubber (Fig. 44) is a circular vessel built up of cast-iron plates of

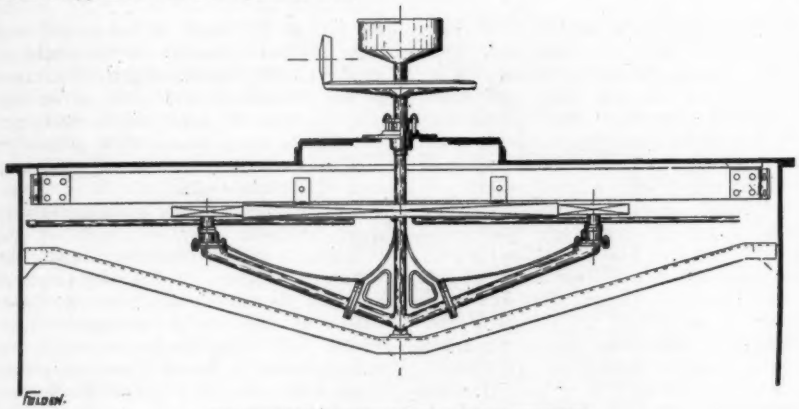


FIG. 45.—GREEN'S DISTRIBUTOR FOR TOWER SCRUBBERS.

a height from 40 to 70 ft., and diameter from 3 to 12 ft., both height and diameter varying in accordance with the quantity of gas to be dealt with, and somewhat with the idea of the engineer, as some advocate greater comparative height to diameter; but in any case a Tower scrubber is rarely more than 70 feet high by 12 feet diameter. The cast-iron vessel is merely a shell to contain the scrubbing material, which breaks up the gas into small streams, the surface of the material being kept constantly wetted with the liquid run in at the top. The scrubbing material used was at one time almost exclusively gas coke, but this was found to require frequent renewal, and it is now more general to use wood boards about $\frac{1}{2}$-in. thick and 7 to 9 in. deep, with distance pieces about $\frac{1}{2}$-in. thick, nailed on to keep them apart. The rows of boards on edge are set on each other so as to form a spiral in the scrubber, and one or two rows are omitted every 12 to 20 feet to allow the small streams of gas to unite, when they again break up to pass through another series of boards. In some cases canvas screens are used instead of boards and are said to be very efficient.

It will be seen that if the exposed surfaces of the scrubbing material are to be kept wetted, a very efficient means of distribution must be employed. If the liquid be run in through an open-ended stationary pipe it would find its way down

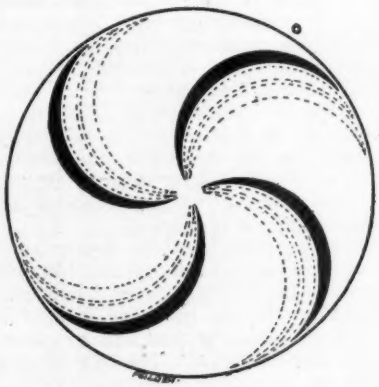


FIG. 46.—DIAGRAM SHOWING DISTRIBUTION OF WATER FROM GREEN'S DISTRIBUTOR.

in very few streams only, and a pipe having a number of small holes is unsatisfactory from the liability of the holes to choke.

Out of the many devices invented to attain this object of efficient distribution the author has adopted one invented by Mr. Henry Green, of Preston. An open-ended pipe is used, being made to revolve while regulating the flow of liquid, so that an even distribution is ensured whether the quantity used be large or small. The following description, with illustration (Fig. 45), will make this clear.

In the centre of the scrubber and close under the top plate is a large fixed spur wheel. Passing through a stuffing box in the centre of the top plate and down through the spur wheel, but not attached to it, is a central supply pipe, having at its upper end a funnel, below which is keyed on to the supply pipe a bevel wheel. A rotary motion is conveyed to this wheel by bevel gearing from any convenient source of power. The central supply pipe rests in a footstep, and from it branch one or two pipes at a V-angle, thus forming a liquid trap to prevent the escape of gas. The branch pipe serves also as a bracket to carry a socket bearing, in which works as a swivel the axis of a small pinion, gearing into the large fixed spur wheel. The axis of the pinion has a passage or port formed through it communicating with a short discharging pipe. The central supply pipe revolving causes the branch pipe to revolve, but in addition the small pinion rotates, being geared into the fixed spur wheel. The number of teeth in the latter are such as not to be exactly divisible by the number in the pinion, thus ensuring a slight variation in the position of the discharging orifice of the arm each time it is to open.

Referring to Fig. 46, if the circular line *O* is taken to represent the circumference of scrubber, the four black curved lines will represent both the track and volume of liquid discharged at four separate points in the first revolution. The dotted lines a little in advance of them will represent the line of discharge at the second and third revolution, and so on, the discharge at each revolution being slightly in advance of the preceding one. The curves not only represent the course of the discharge, but the thickness represents a greater or less discharge to suit the variable area over which it is made.

Of the type of rotary scrubbers a very good example may be seen in the "Eclipse" washer scrubber made by Clapham Brothers, of Keighley (Figs. 47 and 48). It consists of a cast-iron case or shell with semi-circular top, the lower part of the shell being divided internally into compartments by means of cast-iron plates. A shaft runs the full length of the washer, upon which are keyed the revolving cylin ders, one to each compartment. The outer edges of the cylinders are faced and run against corresponding facings inside the case, thus preventing gas slipping by the cylinders and passing direct from one compartment to another. The cylinders are filled with sycamore wood balls, $1\frac{1}{4}$ in. diameter and perforated with $\frac{1}{2}$-in. diameter holes, kept in position by perforated steel plates. Perforated buckets are fixed upon the cylinders, which dip into the liquid at bottom of washer and thoroughly wet the surface of the balls at every revolution. The shaft is carried on bearings outside each end of the shell and on others fixed to each division plate. A tail pin is used to keep the facings on revolving cylinders and case in contact, the efficiency of the machine largely depending upon this to prevent any slip of the gas.

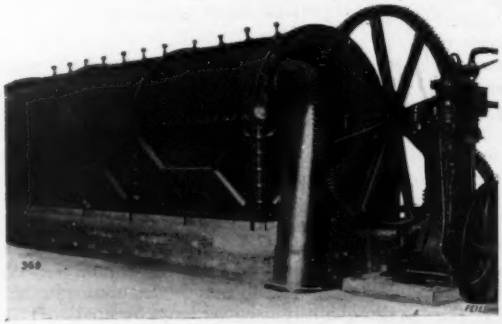


FIG. 47.—CLAPHAM BROTHERS' "ECLIPSE" WASHER SCRUBBER.

The machine may be driven by strap, or geared down direct from crank shaft of a small steam engine.

In this and all other forms of washer scrubbers the principal object is to free the gas from ammonia, which being a valuable product is well worth some trouble to effect. Clean water only is necessary, ammonia being readily absorbed by it, but the gas must be broken into as small streams as possible and presented to ample wetted surface. The clean water, entering the washer scrubber at

the end where the cleanest gas leaves, should take up the last traces of ammonia, becoming more and more impregnated as it travels through the machine until it leaves at the end where the gas enters.

As the water becomes impregnated with ammonia it also absorbs some portion of carbonic acid and sulphuretted hydrogen, and to such extent lightens the work of the purifiers proper.

Another excellent type of the rotary scrubbers, and one having some distinct improvements over the last described, is the "New" washer scrubber manufactured by W. C. Holmes & Co., of Huddersfield (Figs. 49 and 50). It does away completely with the faced surfaces of metal running in contact, is lighter, requires less driving power, and offers an enormous washing surface. It is a cylindrical vessel composed of cast-iron plates, the length being twice or thrice the diameter. Inside are ranged a series of wrought-iron plates $\frac{1}{4}$ in. thick, alternately fixed between the flanges of the cylinders and to the driving shaft running from end to end of the scrubber. The shaft is supported on brackets outside each end of the machine, and also midway on a cast-iron stand fixed to bottom of cylinder. To the iron plates attached to the shaft are fixed circular brushes (Fig. 52) made of South African Gaboon Piassava. These, continually revolving, dip into the liquid in the lower portion of the several chambers formed by the plates fixed between the flanges of the case, and supply freshly wetted surface through which the gas passes. The brushes are made to give a $\frac{1}{4}$-in. thrust on each of the division plates, to prevent slip of gas without passing through the brushes. Between the chambers and separating them one from another is a small "still" chamber, which in practice it is claimed enables the ammonia water to be worked up to a greater strength. The washer is

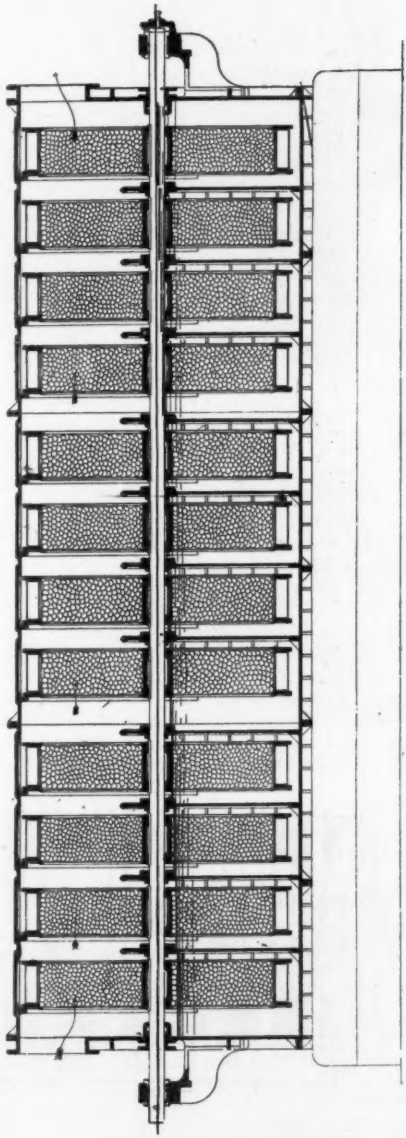


FIG. 48.—LONGITUDINAL SECTION THROUGH CLAPHAM'S "ECLIPSE" WASHER SCRUBBER.

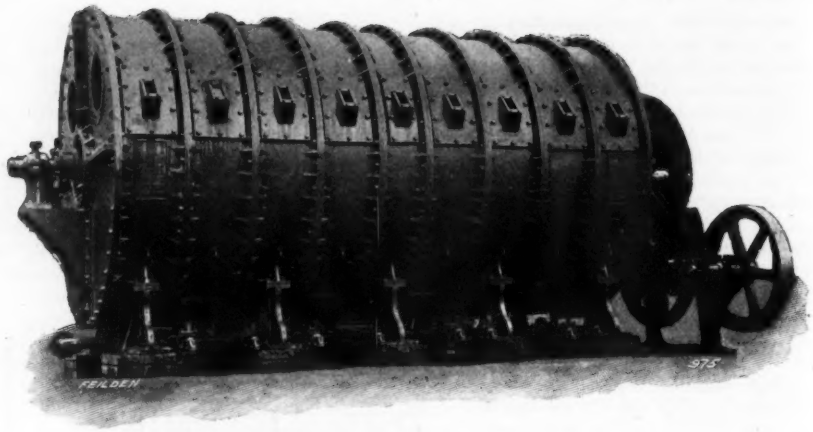


FIG. 49.—HOLMES' "NEW" WASHER SCRUBBER.

driven with helical spur gearing by a small horizontal steam engine.

Where ground space is limited, this washer scrubber is made in vertical form (Fig. 51) and is stated to be equally efficient.

The "Standard" washer scrubber of Kirkham, Hulett & Chandler (Figs. 53 and 54), is one of the earliest of the rotary type, and has gone through a succession of alterations and improvements. In the form in which it is now made it consists of a cylindrical horizontal vessel divided into compartments by vertical division plates, which have circular openings at the centre to permit the passage of the gas. The shaft, which runs the length of the machine, is provided with *lignum vitæ* bearings. To it is keyed in each compartment a strong cast-iron collar, and to this is attached a wrought-iron frame carrying the scrubbing material, which consists of bundles of wood boards $\frac{1}{8}$ in. thick kept $\frac{3}{16}$ in. apart by wood deflector pieces. In the latest devices these deflector pieces are notched out at one end, so as to pick up the washing liquid and distribute it over the wood boards at every revolution.

As in the "Eclipse" washer, the effectiveness of the machine largely depends upon

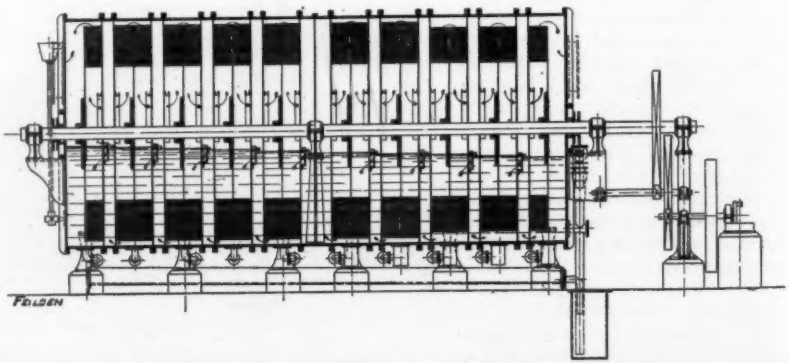


FIG. 50.—LONGITUDINAL SECTION OF HOLMES' "NEW" WASHER SCRUBBER.

the faced joint between the division plates and revolving collars. In this case, however, the faced joint is much nearer the shaft, and a felt ring (see Fig. 55) is attached to the division plate and presses against the facing on revolving collar, the faces of the metal being kept $\frac{1}{8}$ in. apart.

Special arrangements are made to ensure circulation of the liquid in the washer and prevent accumulation of tar, in addition to which a tar extractor can be fixed in the first chamber if necessary.

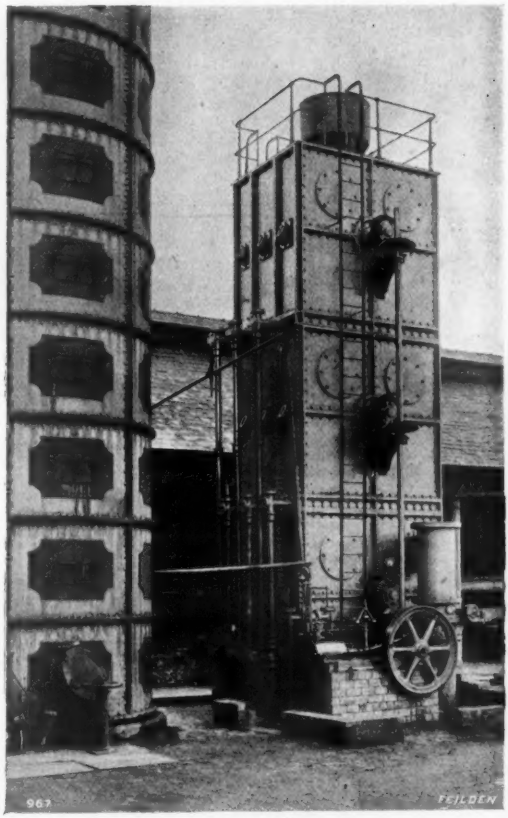


FIG. 51.—HOLMES' "NEW" VERTICAL WASHER SCRUBBER, FOR USE WHERE GROUND SPACE IS LIMITED.

PURIFICATION.

The method of purification of coal gas depends upon the degree of purity aimed at, or the obligations laid by Parliament upon the owners of gas works.

The Metropolitan gas companies are under restrictions to supply gas free from sulphuretted hydrogen, and which does not contain more than 4 grains of ammonia per 100 cubic feet of gas, nor more than 22 grains of sulphur (in other forms than sulphuretted hydrogen) in winter, and 17 grains in summer; and there are numerous testing stations at which daily tests are made to see that these restrictions are complied with. These restrictions apply also to most of the suburban and provincial gas companies, though there are a few notable exceptions. As a rule, local authorities who own gas works are not so restricted, though in most cases some form of sulphur purification is adopted, but, as may be supposed, not nearly so strictly adhered to as in the case of companies who are rigidly

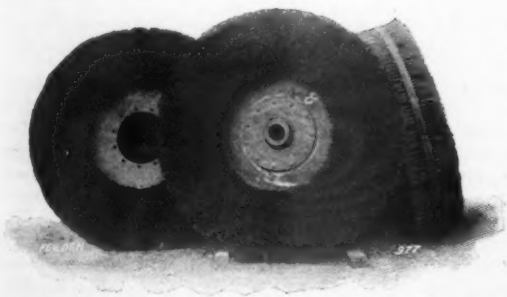


FIG. 52.—BRUSHES SECURED TO REVOLVING PLATES FOR HOLMES' WASHER-SCRUBBER.

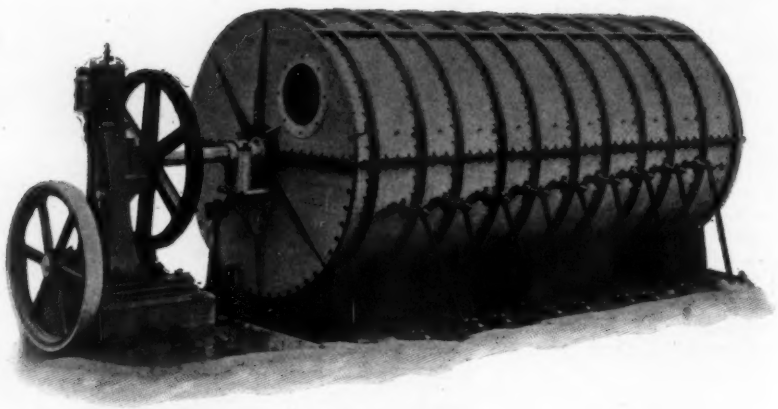


FIG. 53.—KIRKHAM, HULETT AND CHANDLER'S "STANDARD" WASHER SCRUBBER.

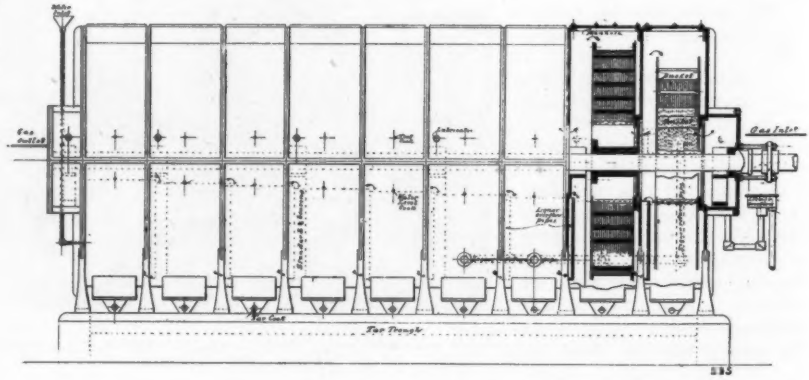


FIG. 54.—LONGITUDINAL SECTION OF KIRKHAM, HULETT AND CHANDLER'S "STANDARD" WASHER SCRUBBER.

tested and are liable to penalties for infringement.

Ammonia is easily eliminated to a much lower point than the legal limit by the use, as already stated, of clean water, and if the only other impurity to be removed were sulphuretted hydrogen, it could easily be accomplished by passing the gas through oxide of iron. But there still remains, in addition to the sulphur compounds, carbonic acid, which, though not injurious to health in the small quantities existing in coal gas, is yet very prejudicial to its illuminating quality, and is therefore almost always partially removed, the method generally adopted being to use sufficient lime for reducing the carbonic acid and then oxide of iron to completely remove the sulphuretted hydrogen.

So far purification of coal gas is simple enough, but in dealing with the sulphur compounds in other forms than sulphuretted hydrogen much more difficulty is experienced, and the purification must be

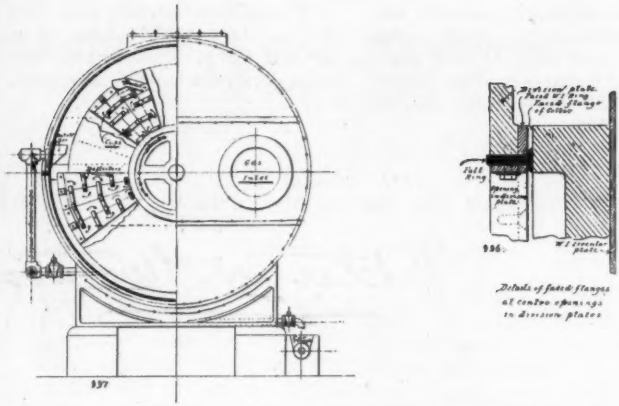


FIG. 55.—SECTIONS OF KIRKHAM, HULETT AND CHANDLER'S "STANDARD" WASHER SCRUBBER.

accomplished practically with all lime—a process far more expensive than when a considerable quantity of oxide of iron can be used.

The outcry that was raised against sulphur and its deleterious influence upon health, which led to the stringent legislation limiting the quantity in purified coal gas, was a costly one in results to gas consumers, and, the author believes, without adequate benefit for the expense involved.

The following extracts, from a recent report of a well-known chemist upon the subject, will show the very small amount of sulphurous acid produced in gas-lighted rooms from the combustion of sulphur in coal gas :—

"The practice of stating the quantity of sulphur remaining in purified gas in grains per 100 cubic feet of gas does not convey to the general mind a clear idea either of its relative amount or actual importance.

"Gas weighs approximately 240 grains per cubic feet, therefore 40 grains are equivalent to one part in 600 parts. Expressed as volumes, the proportion is seen to be still more insignificant. In the gaseous form sulphur weighs about 1,200 grains per cubic feet, therefore 40 grains of sulphur equal one part in 3,000 parts by volume.

"The utter insignificance of a few grains more or less of sulphur is, however, best seen on considering the extent to which the atmosphere is vitiated by its combustion; and it is, of course, only on this account that the sulphur is objected to. Forty grains of sulphur yield on combustion 80 grains, or $\frac{1}{14}$ of a cubic foot, of sulphurous acid. But the combustion of 100 cubic feet of gas produces also 60 cubic feet of carbonic acid, so that the sulphurous acid forms only $\frac{1}{860}$ part of the whole gaseous products of combustion. Even where no special means of ventilation are provided, diffusion is constantly taking place through crevices and the porous walls of a gas-lighted room, so that the amount of those impurities actually existent in the atmosphere of a room is exceedingly small. The amount of sulphurous acid is altogether too minute to be directly estimated; but, knowing the ratio it bears to the carbonic acid, it is possible to arrive at the amount indirectly."

Referring to experiments made to determine the carbonic acid present in the air of gas-lighted rooms, the report goes on to say :—

"Under the worst conditions, this impurity never amounted to one part in 500 parts of air, and only rarely exceeded one part in 1,000 parts. From this it would seem that when gas is burnt containing 40 grains of sulphur the atmosphere may be contaminated with sulphurous acid to the extent of one part in 900,000 parts, but the proportion will certainly not amount to one part in 450,000 parts.

"It is quite probable that this minute trace of sulphurous acid is beneficial rather than otherwise, by reason of its destructive action on disease germs present in the air."

It must be remembered that it is not possible to remove all the sulphur present in coal gas, but only to reduce it about one-half—that is, instead of the air in unventilated gas-lighted rooms containing a possible one-half-millionth part of sulphurous acid, it can be reduced to a possible one-quarter-millionth part, and the cost of

so reducing the sulphur is certainly not less than one halfpenny for every 1,000 cubic feet sold. For such a paltry gain, therefore, the gas consumers of the Metropolis *only* pay the huge annual sum of upwards of £68,000.

Throughout Germany and most of the Continental gas works oxide of iron only is used for purification, and the sulphur compounds are ignored altogether.

(To be continued.)

Fletcher W. Stevenson

Pneumatic Tools and Appliances.

By EWART C. AMOS, M.I.Mech.E.

❀ ❀ ❀

FURTHER TYPES OF COMPRESSORS AND HAMMERS—RIVETERS.

(Continued from page 175.)

WHILST there are many types of air compressors on the market, they do not all fulfil the conditions necessary for economically supplying air for the purpose of driving pneumatic tools; in fact it may be said that the advent of the pneumatic tool has created a new demand for air-compressing plants, and moreover that users will find the value of such a supply of energy for purposes where previously they had used steam, as, for instance, in driving pumps, also for many kinds of lifting devices, &c., some of which will be described in these articles. Before concluding remarks on air compressors reference must be made, as promised, to one more type, viz.:—the "Reavell," which is illustrated in the accompanying diagrams, of which Fig. 24 shows a general view of a belt-driven machine of this description having a capacity of 60 cubic feet of free air per minute. It is designed somewhat on the lines of the three-cylinder compressor which was described in the last article, but by referring to Figs. 25 and 26 it will be seen that it is fitted with four single acting cylinders instead of three. It is claimed for the four cylinder arrangement that it provides an easier belt drive since there are four instead of three separate deliveries of air per revolution, and that practice bears out this claim. It is, moreover, the case that the tank or frame in which the cylinders are carried is practically the same size for four cylinders as for three, and since the addition of the fourth cylinder but slightly increases the total weight, it may reasonably be assumed that from the point of view of weight in relation to power, the four cylinder type has the advantage.

Coming now to the details of construction, the cylinders are fitted with trunk pistons with their connecting rods all working on to a common crank pin. These connecting rods are made from mild steel, and all the working parts of the

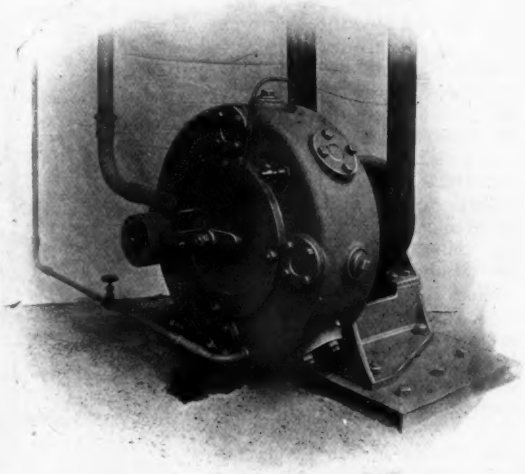


FIG. 24.—"REAVELL" TYPE FOUR-CYLINDER BELT-DRIVEN COMPRESSOR.

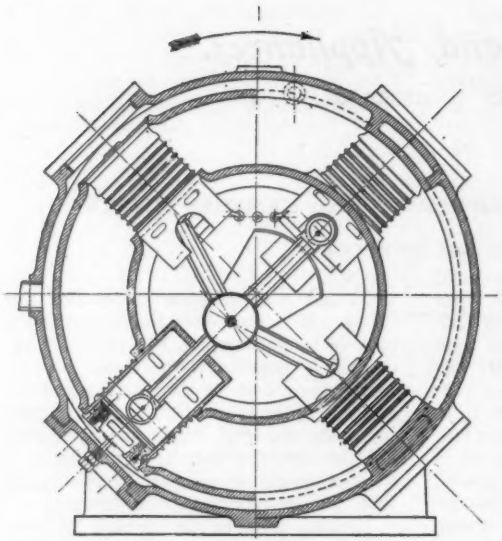


FIG. 25.—CROSS SECTION OF "REAVELL" COMPRESSOR.

compressor are so arranged that they may be easily detached if desired. The cylinders are single acting, and are each fitted with four straight lift delivery valves opening away from the pistons, and delivering into a chamber which is common to all of them, and connected to the supply pipe of the receiver. In the centre of the piston is a small port, through which air is taken into the cylinder when a similar port in the cross-head of the connecting rod is in line with it. The rock of the connecting rod regulates the air admission, as is usual in engines or compressors of this type. In order, however, to ensure that the full charge shall be taken in before compression commences, a series of slots formed in the body of the cylinder, and communicating with the interior of the casing, are uncovered just before the piston has completed its outward stroke.

The interior of the casing in which the cylinders are mounted is open to the atmosphere, excepting when closed by a circular grid valve, which forms part of the automatic controlling device, and which will be described later on. The action of taking in, compressing and discharging the compressed air is therefore as follows, and taking one cylinder for the purposes of description (since the action is the same in all), and assuming that it has just commenced its outward stroke, the four valves at its closed end will remain shut, whilst atmosphere will rush in through the crosshead port, *viâ* the piston, to fill the cylinder as the piston travels out: as it nears its extreme outward point, the crosshead port closes, but the slots in the cylinder already referred to permit of a further intake of free air. As soon, however, as the piston returns slightly, these ports are again covered and compression commences and increases until

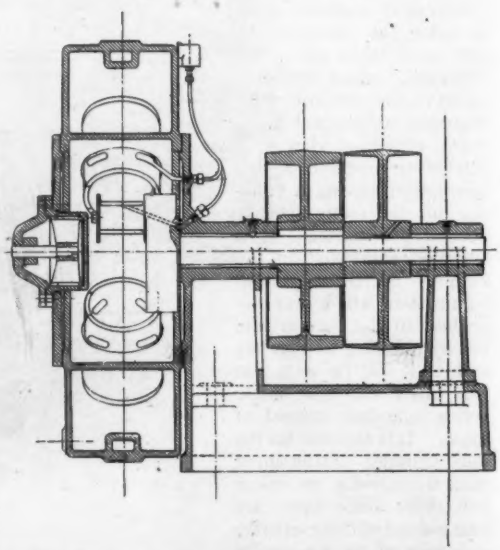


FIG. 26.—LONGITUDINAL SECTION OF "REAVELL" COMPRESSOR.

a pressure is obtained equal to that in the receiver, when the four delivery valves open, and the charge is delivered into the supply pipe up to the point of completion of instroke, when the action is again repeated. It has already been pointed out that some form of automatic constant pressure controlling device is a feature of all compressors used for supplying air to drive pneumatic tools; and the system adopted in the "Reavell" type takes the form of a valve controlling the opening into the interior of the tank or casing from which the cylinders obtain their air supply. This valve is shown in section in Fig. 26, and it is obvious, therefore, that when it is closed the air in the interior of the casing, after a few strokes, becomes much rarefied, so that the charge when compressed is not sufficient to open the delivery valves; moreover, that no work is done beyond overcoming the friction of the moving parts, since what takes place is simply an alternating rarefaction and compression of the air. By this arrangement the compressor receives just the exact quantity of air that is necessary to suit the variable requirements of pneumatic tools, whilst, at the same time, it permits of regular and continuous running of the compressor (as in the "Curtis" type).

The construction and action of the controlling device is as follows: Referring to the illustration, Fig. 24 shows a 60 ft. compressor, having a flat circular grid valve, whilst Figs. 25 and 26 are sections taken through a 90 ft. compressor, and having a differently shaped valve, as in this case it will be noted it is hollow, with the ports on its periphery. The valve, however, pivots on a spindle in both cases, and in action is practically the same. To one end of this spindle is a balanced double-ended lever, carrying at one end a weight and with its other end pressing against the piston of a small cylinder supplied with air from the casing or tank. This device is very clearly shown in Fig. 24, in which the connecting air pipe to the small cylinder is seen entering the top of the casing where it communicates with the delivery pipe. Its action is simple, since as soon as the pressure in the delivery pipe exceeds the normal, it depresses the balanced lever, and in so doing revolves the circular grid valve, which closes communication from the atmosphere to interior of casing.

In connection with this question of maintaining a constant pressure, it will have been noticed that some makers adopt a belt-shifting device, whilst others control the air supply; advantageous as it may seem to bring the compressor to rest when doing no work, yet it must not be forgotten that generally speaking the output of the compressor is suited to the desired supply, and is therefore nearly always at work. Again, a belt-shifter, if sensitive enough to secure anything like a constant pressure, is perpetually on the move, which necessarily soon destroys the belt; or on the other hand, if such a device be not sensitive, the variation in the receiver becomes excessive before shifting of the belt takes place. It must also be remembered that the working parts of a belt-shifter are generally more complicated than those of an air controlling device, and moreover, require live air for the operation. Both methods claim their advocates, and both are mechanically practicable, but the advantages preponderate on the side of the air controlling device.

In the December issue of this Magazine several of the principal types of hammers were described and illustrated, and amongst these was the "Little Giant," to which, however, it was only possible at that time to make but brief reference. This hammer is now being manufactured in England, and further information regarding it, together with sectional views, will, doubtless, prove interesting, more especially as it embodies some important features in construction, and also in respect to the method adopted for cushioning the moving parts. This is effected by throttling the exhaust instead of the admission of live air, as is done in most of the other hammers, and considerable economy in air consumption is secured in this way. Referring to the diagrams, Fig. 27 is taken from a photograph of the latest pattern of the "Little Giant" type of hammer. Fig. 28 shows a longitudinal

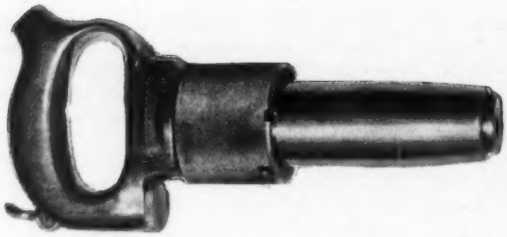
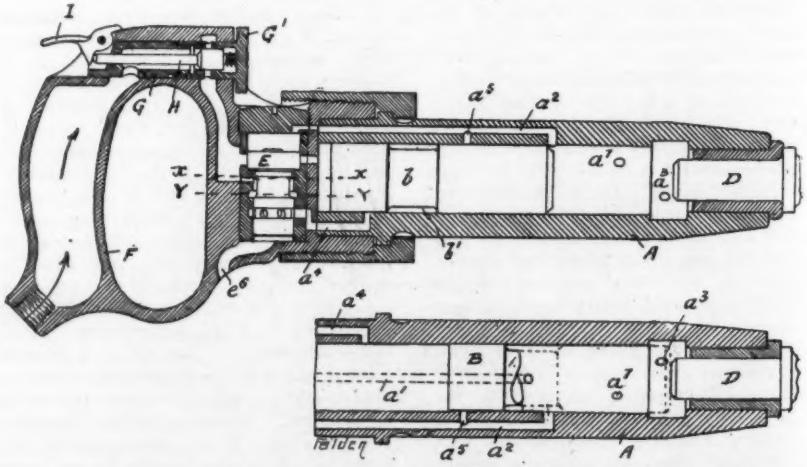


FIG. 27.—"LITTLE GIANT" HAMMER. LATEST PATTERN.

sectional elevation of a similar hammer, with the striking piston at the rear end of its stroke, and with the valve in its top position. Fig. 29 is a similar view of the cylinder portion of the hammer, but of the opposite half, and showing the striking piston at its forward end of stroke. Figs. 30 and 31 show the handle and valve portions in section, with the valve at top and bottom positions respectively. Figs. 32 and 33 show horizontal sections taken on lines *X* and *Y* of Fig. 28.

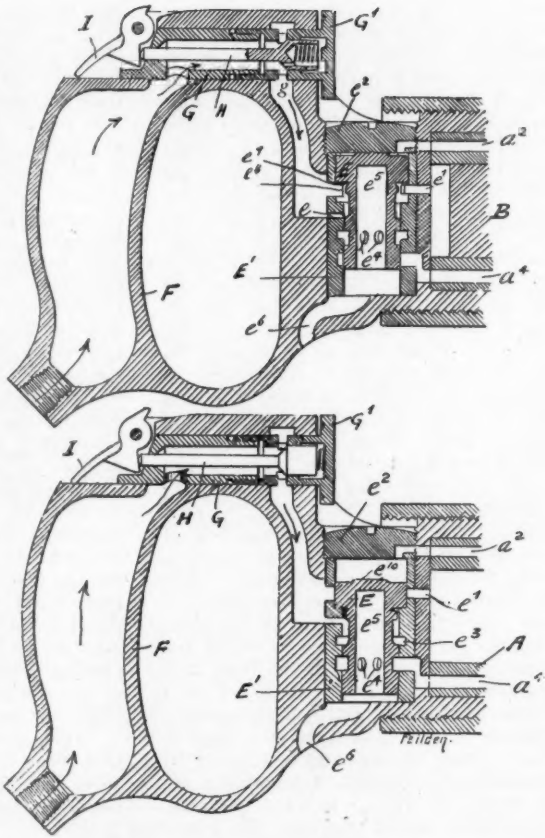
The following letters of reference indicate like parts in each view:—*A*, working cylinder; *B*, piston hammer; *D*, working tool; *E*, controlling valve; E^1, steel seating for same; *F*, handle; *GG*^{1}, throttle valve bushing; *H*, throttle valve; *I*, trigger actuating same; *a*, bore of cylinder; a^1, passage leading from space *e* to the cylinder, and always full of fluid pressure when throttle valve is open; a^2, passage leading from cylinder to top of valve chamber; a^3, passage from front end of cylinder to annular space e^3 in valve chamber; a^4, exhaust passage at rear end of cylinder leading to exhaust through interior of valve; a^5, bye-pass from a^2 to cylinder; a^6, bye-pass from cylinder to a^7; a^7, exhaust passage to forward end of cylinder to atmosphere; *b*, reduced portion of striking piston; b^1, annular chamber formed by such portion; *e*, opening into the controlling valve bushing; e^1, opening into cylinder from valve bushing; e^2, cap on top of valve bushing; e^3, annular portion in valve bushing; e^4, opening in valve *E* leading to exhaust port e^6; e^5, central chamber of valve; e^6, exhaust to air in handle; e^8, enlarged diameter of valve for cushioning; e^9, recess behind e^8; e^{10}, small boss on top of valve.

The action of the tool is as follows:—Fluid under pressure having been admitted by operating the valve *H*, passes through the opening *e*, and under the head of the

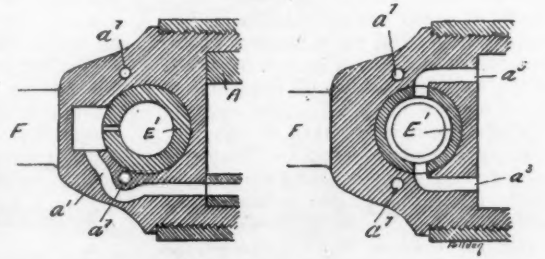


FIGS. 28 AND 29.—SECTIONS OF "LITTLE GIANT" HAMMER.

valve E, thus forcing it into the position shown in Fig. 30. The air is then able to pass into the cylinder, through the opening e^1, and this forces the piston forward into the position shown in Fig. 29. It will be noted that the piston is reduced in diameter at b, which, together with the cylinder, forms a chamber b^1, so that as the piston nears its forward limit of stroke, fluid pressure enters the chamber b^1 from the passage a^1, which is in direct communication with space e. At the same time the passage a^2 is brought into communication with b^1, and thus the air passes along the top of the valve E, and forces it into the bottom position, as shown in Figs. 28 and 31. When the valve is in this position a clear way for the compressed air is open to the front end of piston through e, e^3, and a^3, thus effecting the return of the piston. Thus far the live air admission has been dealt with to drive both piston and valve in both directions. Coming now to the exhaust, and taking the piston in its rearward motion first, the air escapes along the passage a^4, and through the openings e^4 in valve, and out through e^6. In its forward motion the piston exhausts first through a^7, which leads direct to outer atmosphere, see Fig. 29. When a^7 is passed the air escapes through a^3, which is open to atmosphere through e^3, e^4, and e^6, when the valve E is up. The exhaust of the valve is effected



FIGS. 30 AND 31.—"LITTLE GIANT" HAMMER. SECTIONS THROUGH HANDLE AND VALVE PORTIONS.



FIGS. 32 AND 33.—"LITTLE GIANT" HAMMER. HORIZONTAL SECTIONS ON LINES X AND Y OF FIG. 28.

thus :—During the backward movement of the piston, and as its annular portion is passing a^2, it permits the fluid pressure on top of the valve E to escape through a^3, a^4, into b^1, a^6 and a^7, to the atmosphere, with result that superior pressure under valve head from e again lifts the valve. The valve is forced into its bottom position due to its area on the top being larger than the ring underneath its head. It is obvious that both the striking piston in its backward stroke and the valve in both directions should receive some form of cushioning, so as to reduce shock and prevent injury to valve and cylinder. In the piston this is effected by its closing the port a^4 before the end of its stroke. In the valve the desired cushioning is secured in its upward stroke by means of the boss e^{10}, which causes the air to escape rather slowly into a^5. In its downward stroke the cushioning is effected thus : The portion e^8 of the valve E is of a diameter nearly equal to the small bore of the valve bushing, and there is also provided a small groove e^9 as shown. When the valve is moving down the portion e^8 first enters the small bore of the valve chamber, and this tends to retard the passage of the air through the bore, and permits the excess of air to act as a cushion. Up to a certain limit the same hammer may be used to give light or heavy blows, and this may be effected by regulating the amount of opening given to the throttle valve. It is not desirable, however, to simply rely upon the trigger to do this, but preferably to provide a regulator, so that however hard the trigger may be pushed it only opens the valve the desired amount. In the "Little Giant" Hammer this result is obtained by making the throttle valve bushing in two portions, G and G^1. The part G is fixed to the handle F, whilst G^1 is capable of being screwed in or out. The effect of this adjustment, when taken in combination with the valve H and the trigger I, is such that when G^1 is unscrewed the port g^1 may be moved into such a position that the valve H can be pushed by the trigger I to the limit of its stroke without uncovering the port g^1 at all, and by adjustment of the part G^1 any desired opening may be given for the admission of air. In order to put the valve H in equilibrium a small opening admits the compressed air to either side of it, which, together with the spring shown, effects the desired result.

It will be obvious that fewness of parts, and especially of joints, is a desideratum in the design of a tool using compressed air at a high pressure, since the possibility of leakage is thereby reduced. So far as fewness of parts is concerned, the valve less hammers have undoubtedly the advantage, and they have also probably a longer life than the valve hammers, but it is generally recognised that when a heavy blow is necessary, the valve hammers give the best results, as it is possible to give them a longer stroke, and whatever loss may be sustained in the ports, or dis advantages incurred in an increased number of parts, they will do work for which the valveless hammer is inefficient. At the same time, wherever a joint can be dispensed with is an advantage gained, and it would appear that the danger from leakage is reduced to a minimum in the type under consideration, as it will be noted the valve bushing is inserted direct into the body of the handle, thus dispensing with a valve block, whilst the cylinder portion is securely fixed to the handle by means of a sleeve.

It will have been noted in the description given, that the automatic-controlling valve E is caused to close the port a^4 before the piston completes its rearward stroke; this has the effect of bottling up a certain portion of the air, which acts as a cushion to prevent the piston striking the end of cylinder. In some hammers the same result is obtained by admitting live air before the piston has completed its stroke, but the throttling of the exhaust is certainly more economical.

Referring to the valve, this is also provided with an air cushion to prevent any knock that might otherwise take place, and this, coupled with its solid construction, should secure for it a long life.

PERCUSSIVE ACTION RIVETERS.

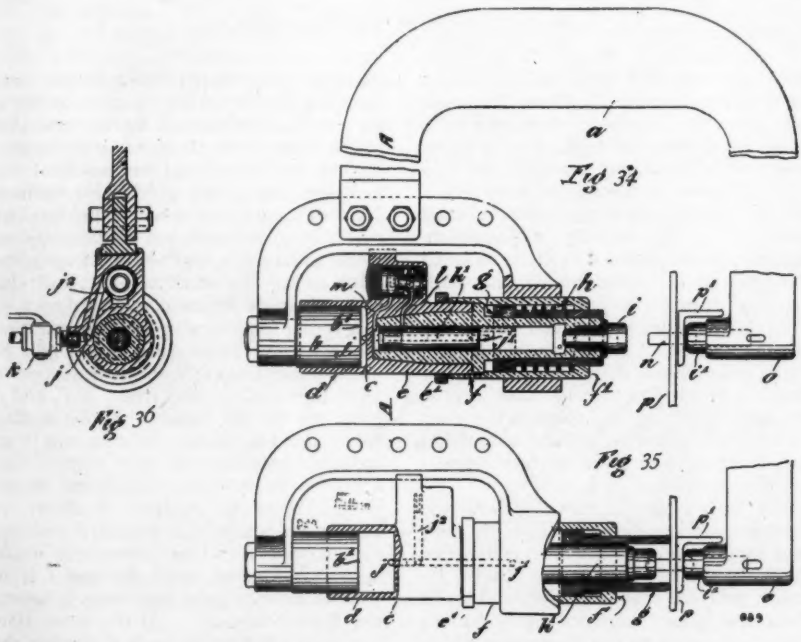
HAND TYPE.

The ordinary Percussion Hand Riveter *per se* is nothing more nor less than a

heavy pattern hammer of the types already described, and such a one was illustrated in the December issue. It is exceedingly useful for a great variety of work, which previous to its advent was done by hand. It is necessary, of course, to use some form of holder-up, either solid or pneumatic, to keep the rivet in place during the process of riveting. This form of riveter has proved to be of immense value for shell riveting in ship construction, &c., and in conjunction with a gimbal or suitable pivoted frame, permits of shell rivets being driven up to a considerable size, and in places where a yoke riveter is unworkable. In view, however, of the full description which has already been given of the hammer, it is unnecessary to further describe them. It may be interesting, however, to mention that seventy $\frac{7}{8}$ in. diameter rivets can be driven per hour per riveter when using a hammer of the type referred to.

YOKE TYPE.

For riveting in connection with shipwork, constructional ironwork, also for tanks, gas-holders, and a variety of purposes which will readily suggest themselves, this form of percussion riveter has been found very useful. It consists of a yoke made of tube, lattice, or other suitable method of construction, at one end of which is mounted a percussion hammer, whilst at the other is a solid or pneumatic holder-up, suitable provision being made for adjusting the distance between the snaps. Such a riveter, whilst having a large field of usefulness, does not provide for closing the plates, nor holding them in position during the process of riveting, and up to the present very little has been done in this direction, so far as percussion riveters are concerned. Figs. 34, 35, and 36 show a "Little Giant" plate-closing percussion Yoke riveter, which is, however, distinctly a step in the right direction,



FIGS. 34, 35 AND 36.—"LITTLE GIANT" PLATE-CLOSING YOKE RIVETER.

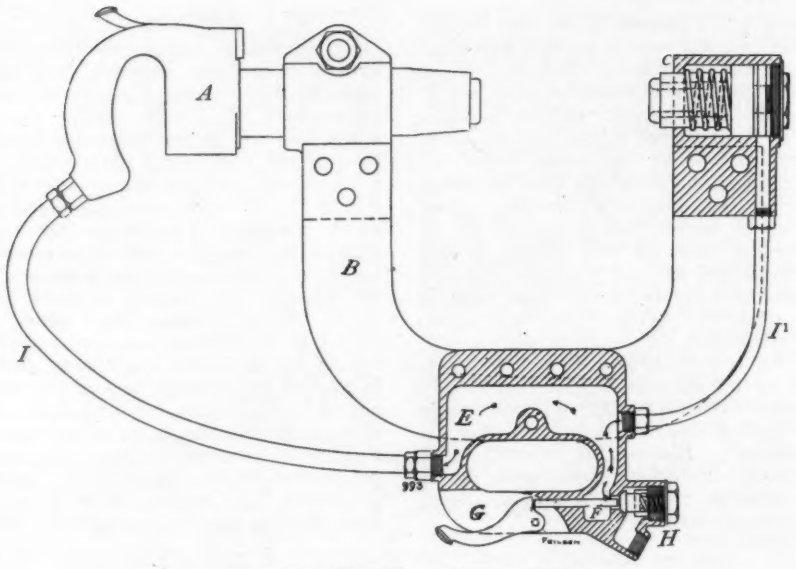


FIG. 37.—"LITTLE GIANT" LIGHT YOKE RIVETER.

and has achieved the object sought for within certain limits, although it does not claim to compete with hydraulic squeezing riveters for high pressure boiler work. This riveter consists of an ordinary yoke *a*, having at one end a fixed holder-up, and at the other a small frame or yoke carrying a pneumatic hammer, and provided with a special clamping device for clamping the work together during the process of riveting. This clamping device also takes the place of the ordinary pneumatic holder-up. Fig. 34 shows the device in section and the rivet in position with its head against the fixed holder-up, and through the work to be riveted together, whilst the hammer and clamping device are in their normal position before live air is admitted.

Fig. 35 is a similar view, but with the clamping device shown against the work in readiness for the hammer to commence the operation of riveting the head. Its action will be readily understood by a short description, reference being had to the letters shown on the diagram, in which *a* is the main yoke; a^1 the small yoke or frame carrying the percussion hammer and clamping device; *b*, a projection of a^1; *c*, an air chamber formed by the extension of the back of the hammer and the projection *b*; *d*, the said extension of the hammer casing, and which also forms a guide to carry the hammer; *e*, the hammer cylinder; *f*, an extension of the coupling sleeve of hammer, and which slides in the other end of the small yoke a^1, and also acts as a guide for the clamping device *g*; *h*, a spring for returning *g* to normal position when the air-pressure is cut off; h^1, the hammer piston; *i*, the tool shaped to form the head of the rivet; j, j^1, and j^2 ports for the air supply; *k*, distributing valve; *l* and *m*, exhaust and supply as in an ordinary hammer; *n*, the rivet. The action is as follows:—The work to be riveted being in position as shown in Fig. 34, air is admitted through *k*, and into the passage *j*. This forces the whole apparatus forward until the tool *i* is in contact with the rivet, and forces it against the fixed holder-up. At the same time live air is admitted through j^1, forcing the clamping device *g* forward, as shown in

Fig. 35, which closes the plates, and permanently holds them in position whilst the rivet head is being formed. As the rivet gets shorter the constant pressure in the space *c* keeps the hammer to its work. The action of the hammer has already been described, the air supply to the striking piston being regulated by its valve. Fig. 36 is a section on the line *AA*, and shows the air passage from the valve *k* to the regulating valve, and also to the cylinders.

HAND YOKE RIVETER.

Another form of yoke riveter, which represents one of the latest developments, is shown in Fig. 37. The object of this riveter is to replace the separate holder-up in light riveting work where a yoke is permissible. To deal with such work it has hitherto been necessary either to use a hand riveter and separate holder-up, thus requiring two operators, or else a yoke riveter, which is generally too cumbersome for one operator. Moreover, it ensures that the holder-up first brings the rivet home before the percussion action begins, and also makes it possible to use an ordinary hammer. This would prove a very useful feature should anything go wrong with the percussion mechanism, when the hammer can be easily unclamped and immediately replaced. Its simplicity and value will at once be appreciated by reference to the diagram, in which *A* represents an ordinary standard type "Little Giant" hammer as used for chipping or riveting, clamped to a light yoke *B* carrying at its other end a pneumatic holder-up *C*. There is also clamped to the yoke *B* a small casing *D*, containing an air chamber *E*, valve *F*, trigger *G*, and suitable pipe connections *I* and I^1, for providing compressed air communication with the hammer *A* and holder-up *C*. The action is as follows: The main air supply enters the chamber *E* at *H*, being admitted past the valve *F* by depressing the trigger *G*, and thence passes to the holder-up and hammer handle. The holder-up at once brings the rivet into its place, and the operator then puts the hammer in action in the ordinary way by depressing the trigger *I*. Such a riveter would close 5-16 in. cold rivets or $\frac{3}{8}$ in. hot rivets with a gap up to about 12 in., and can easily be handled by one man. With regard to the respective advantages of percussion and squeezing riveters, especially the hydraulic type of the latter, there is considerable difference of opinion. In this country, we have so long been used to hydraulic squeezing riveters that the percussion riveter at first met with but scant recognition until its advantages were proved, and the author ventures to think that a solution of the difficulty will be found when the true value of each type for its respective work has been fully recognised. To those who have tried both systems the pneumatic percussion riveter has shown itself for certain classes of work to possess advantages in the form of lightness, portability, convenience in manipulation, and other points, over its rival.

(*To be continued.*)

Ewart S. Amos

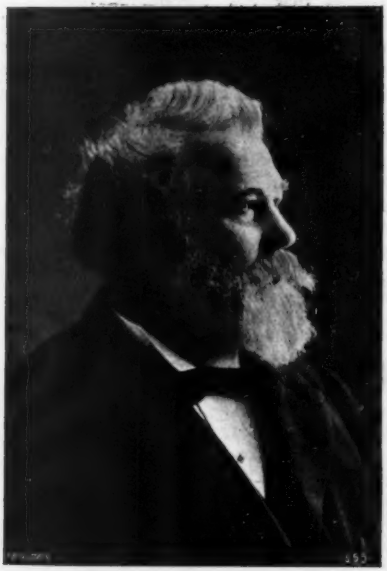
The Building of a Great Railway.

The Great Central Extension to London.

(Continued from page 187.)

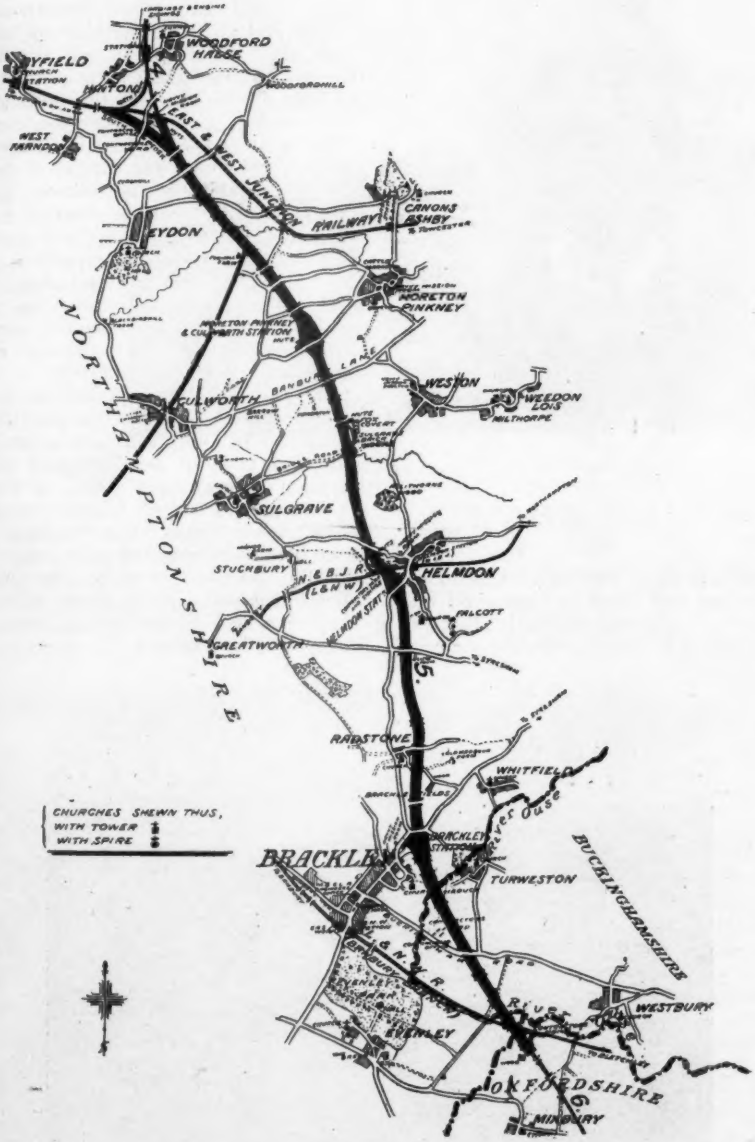
A SHORT distance south of Woodford and Hinton Station contracts Nos. 5 and 6 commence, and include 24½ miles of main line, terminating at the junction with the Metropolitan Railway at Quainton Road, a loop of three quarters of a mile at Woodford forming the south junction with the Stratford-on-Avon line, and a branch of 8¼ miles long commencing on the main line near Eydon and terminating at the junction with the Great Western main line a short distance north of Banbury Station, making a total length of 33⅓ miles. These contracts were placed in the hands of the well-known firm of Messrs. Walter Scott & Co., of Newcastle-on-Tyne and Westminster. The engineers were represented on the works by Mr. C. S. White, A.M.I.C.E., and Mr. H. Colvin-Smith, A.M.I.C.E.

Contract No. 4 ends at a point distant 137 miles 34 chains from Manchester, the initial portion having been deducted from contract No. 5 and given to contract No. 4 by a mutual arrangement. This



WALTER SCOTT, ESQ
(Of the firm of Messrs. Walter Scott & Co., Newcastle-on-Tyne.)

C. T. SCOTT ESQ.
(Of the firm of Messrs. Walter Scott & Co., Newcastle-on-Tyne.)



MAP OF CONTRACT NO. 5, GREAT CENTRAL RAILWAY

MR. J. T. MIDDLETON.

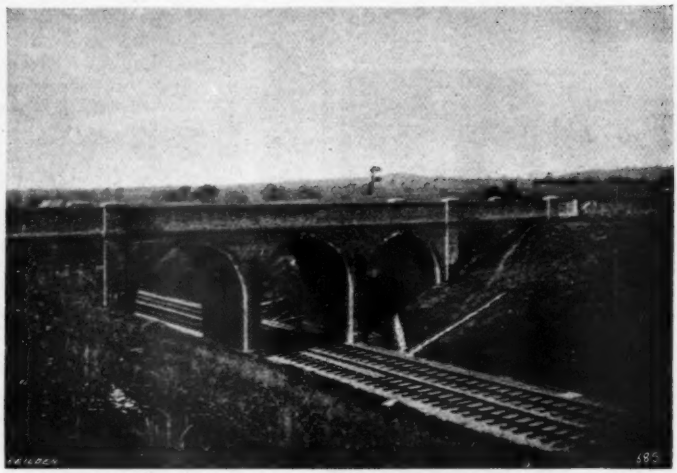
(Head Agent to Messrs. Walter Scott & Co.)

course was found necessary owing to the difficulties that arose in connection with the bridge under and carrying the East and West Junction Railway, whereby the completion of the cutting to the north of the bridge would have been considerably delayed had all the material to be taken south and under it. It was decided, therefore, to run the greater portion of the material to spoil at the north end of the cutting.

The East and West Junction Railway crosses at this point in a cutting of some 10 feet in depth, which necessitated again undercutting by the Great Central Railway to give a headway of 15 feet from the rails to the underside of the girders. As the East and West Junction cutting was already of a very wet description, and the soil in the new cutting consisted of running sand and clay silt, the works here were carried on with extreme difficulty.

The whole of the brickwork in wings and abutments had to be put in in trenches, which were sunk down from the formation level of the East and West Junction Railway to a depth of about 15 feet, where a bed of blue clay of fair resistance was found. The trenching was done before anything had been taken out, and the short lengths of brickwork were all toothed, and lengths of old rail and hoop iron left projecting in order to strengthen the bonds.

JOIN OF CONTRACTS 4 AND 5 IN 1897 (LOOKING SOUTH).



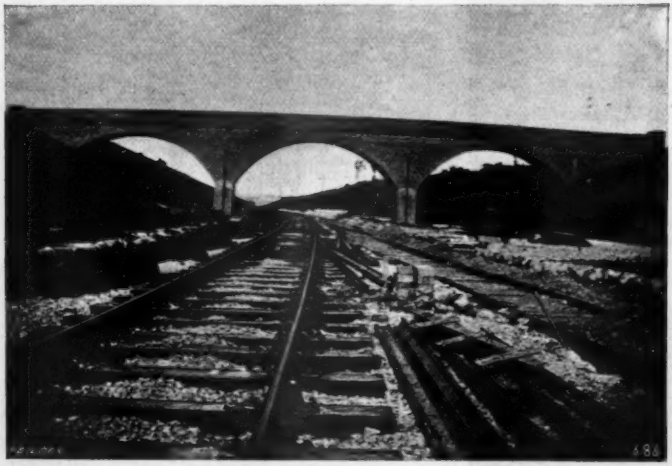
BRIDGE CARRYING THE EYDON TO WOODFORD—HALSE ROAD.

It will be seen from the photograph that the line of the East and West Junction Railway, which is only a single one, was slewed round sufficiently to give free access to the workings.

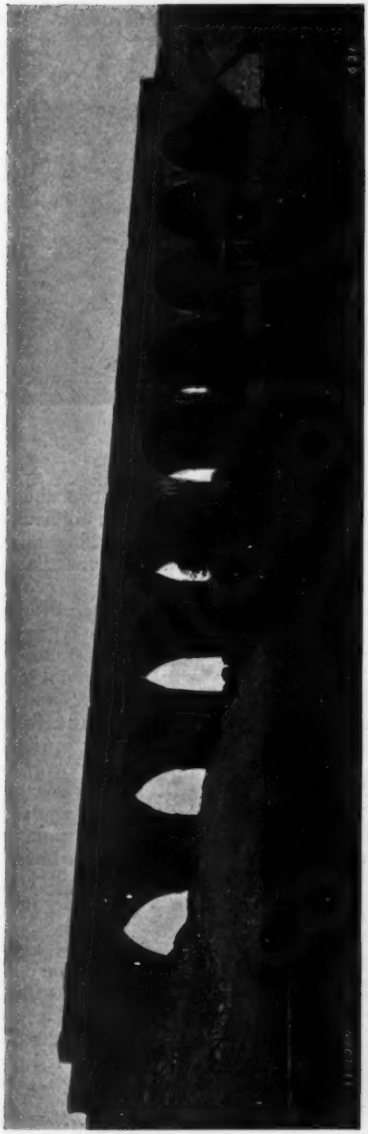
Directly the steam pumps ceased working the foundations filled up with mud and slurry, and it was necessary, therefore, to put the whole of the brickwork and concrete in cement.

The difficulty connected with any possible squeezing in from the pressure behind the walls was met by placing, after the erection of the bridge and the completion of the cutting, four brick struts, in cement, between the two abutments. The whole of these difficult operations were carried on without any interruption of the traffic on the East and West Junction Railway.

At a short distance from the bridge access is given to this railway by a double line of rails, a junction which, in view of giving a shorter route from London to Birmingham, is likely to develop a special importance. No works of any distinction occur on this branch, except a large three-arch bridge carrying the Woodford-Byfield public road.



FARMERS' ACCOMMODATION BRIDGE,
NORTH END OF MORETON-PINKNEY AND CULWORTH STATION.



HELMDON VIADUCT.

The triangle composed of the fork of the main line with the East and West Junction Railway forming a base encloses land over 14½ acres in area, which has been acquired by the company in view of the increasing importance of this junction in the near future. It is intended to erect thereon workmen's cottages, workshops, etc., when the increasing importance of the junction renders these necessary.

Continuing towards London, the earthworks became increasingly heavy. Public road crossings occur at three points before reaching the Sulgrave embankment, one of the largest on the line, responsible for 432,000 cubic yards of material. The first of the public roads is that from Woodford to Eydon, and is carried over by a square span, plate-girder and jack-arch bridge, 20 ft. between parapets. The bridge carrying the road from Preston Capes to Eydon is of a similar type, while the road from Canon's Ashby to Eydon intersects the railway by a plate-girder under-bridge, with a 25-ft. square span.

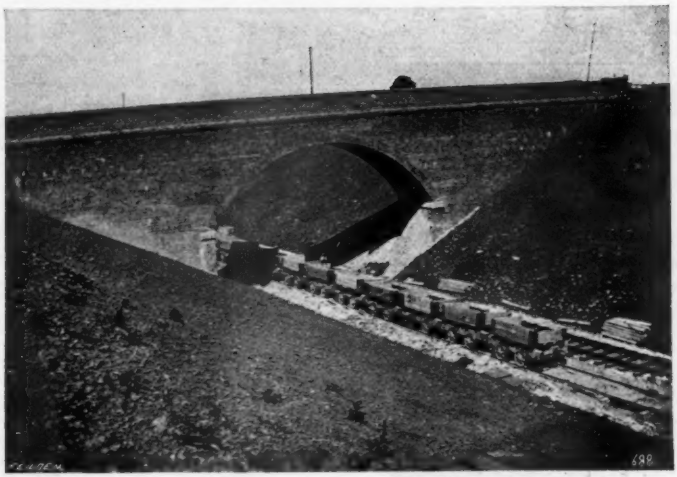
Under the Sulgrave embankment an extensive peat-bog, varying in depth from 5 ft. 6 in. to 8 ft., was encountered. This had to be taken out and well-drained.

At 138 miles 52 chains, the double line to Banbury branches off. In widening the embankment for this junction, in spite of the fact every precautionary measure was taken by the engineers by benching the embankment to receive the extra width, a surface slip took place. This was cured by erecting a concrete toe wall, filling the trenches with rubble, and burning the clay of the top portion of the slip, to lighten it.

Passing points where heavy diversions of public roads were necessary, and an overbridge of the plate-girder and jack-arch type, cutting No. 58 is reached containing, including Culworth Station Yard, 534,000 cubic yards of stiff clay.

This cutting is crossed by a farmers' accommodation bridge, 12 ft. between parapets, of three segmental arches, each having a span of 55 ft. 6 ins.

At a point where the cutting practically disappears, Culworth Station, of the usual country type, is reached, approached from



FARMERS' ACCOMMODATION BRIDGE, BRACKLEY FIELDS.

an overbridge, and serving the adjacent villages of Moreton Pinkney and Culworth. A public road diversion was necessitated by raising the road 17 ft. above rail level. Culworth Station bridge is 25 ft. between parapets, and is of the plate-girder and jack-arch type, having two spans of 29 ft. 9 ins. The extra 3 ft. 6 in. span allows for the widening out of the rails for the island platform.

Leaving Culworth, the line enters on bank No. 86, which is tunnelled by a 12-ft. occupation bridge. Near Sulgrave is a bank containing over 486,000 cubic yards, and two occupation tunnel bridges of the semi-circular 12-ft. arch type pass under it, one of them, constructed for Viscount Valentia, being of unusual length under 43 ft. of embankment.

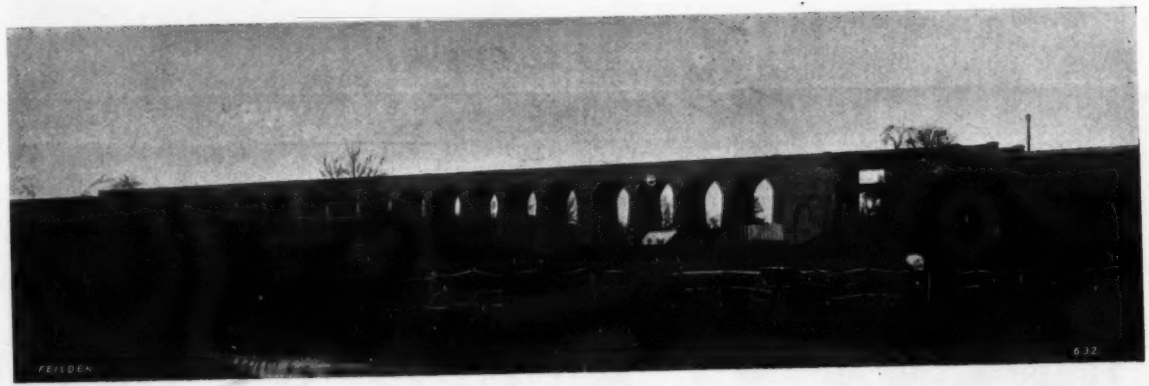
This embankment covers an area of 7 acres and is 340 ft. wide from fence to fence, a fact which startled into wonderment the inhabitants of the district when only the fences had been erected before tipping commenced.

To the east of this point, on 7 acres of land, the contractors erected a complete brick-making plant, which turned out during the thirty-six months of operation some 12,000,000 stock red bricks, practically free from lime and of fair quality.

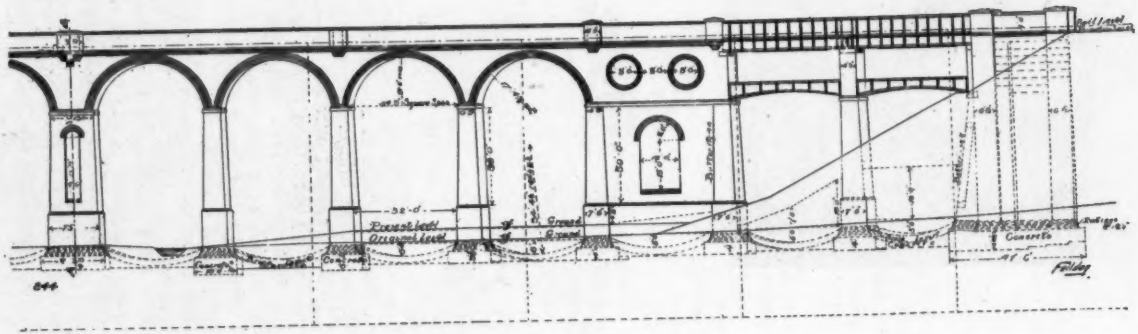
The line is soon again in cutting, which is spanned by a 25-ft. bridge, carrying the public road between Helmdon and Sulgrave. The negotiations for the diversion of this road, which reduced the cost of the bridge by one-third, were carried to a successful issue by Mr. F. Douglas Fox, who was then acting as resident engineer of this section.

The Helmdon Valley is next reached, through which flows a stream liable to severe floods, and intersected also by the Northampton and Banbury branch of the London and North Western Railway. The valley is crossed by two banks, and a viaduct of nine arches, each of 34 ft. 3 in. span, and of the same general design as those at Catesby and Brackley. The treacherous nature of the clay foundations necessitated the distance between the piers being bricked in with five rings of brindle brickwork in cement. The invert under the arch taking the London and North Western Railway was put in in six portions, the rails being supported on longitudinal timbers.

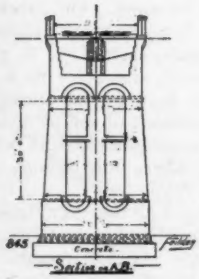
Widening out to 57 ft., the embankment



BRACKLEV VIADUCT (LOOKING NORTH).



PART ELEVATION OF BRACKLEV VIADUCT.



BRACKLEY VIADUCT.

BRACKLEY VIADUCT: THE EFFECT OF THE LANDSLIDE ON AN ADJACENT CEMENT SHED.

A curious movement occurred in the neighbourhood of Brackley Viaduct, caused by some sliding beds of clay below the surface, the effect of which, on an adjacent cement shed, is clearly shown in the illustration.

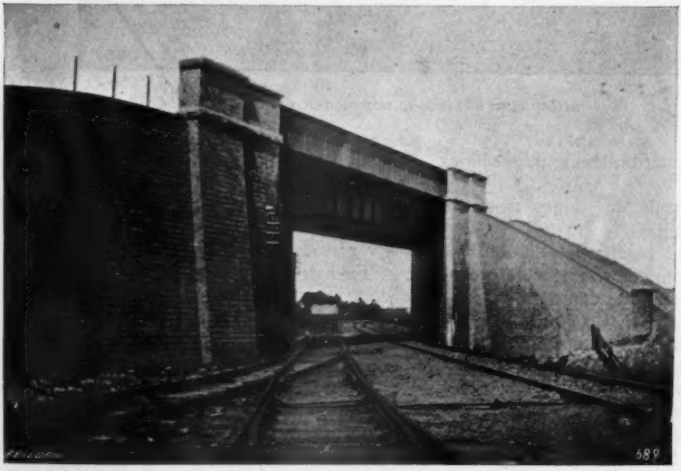
provides accommodation for Helmdon Station (country type), which is approached by an over-bridge of two spans of the steel-plate girder and jack arch type.

At this place the contractors had their branch offices, workshops, running sheds, &c. This site was selected for the convenience of a junction with the London and North Western Railway, but the position entailed a very steep overland route.

The line again enters a cutting containing 445,000 cubic yards, the material of which was composed of blue clay with a bed of disintegrated limestone rock, 15 ft. thick, which was partially utilised for pitching and bottom ballasting.

Nothing of importance occurs between this and the next cutting, where a farmers' road is carried over the railway in 37 ft. of cutting by one large 55 ft. 6 in. segmental arch, with box wings.

The small embankment which follows is interesting, in so far as the first brickwork of the southern division was laid here in the 6-ft. culvert under it, in November, 1894.



OVER THE L. AND N. W. R.'S BANBURY AND BLETCHLEY BRANCH, AND CONTRACTOR'S SIDING.

Leading to Brackley Station is a cutting responsible for 336,000 cubic yards, where a soft friable limestone was encountered with blue clay at formation level, with much water, necessitating two 9-in. cutting drains.

Brackley Station is approached from a side bay in the new Brackley Borough Corporation Road, and is provided with separate and independent arrangements for approach by means of a footbridge. This arrangement was adopted as the Corporation objected to the public road bridge being utilised in the ordinary way, for fear that the station traffic might block the bridge.

This station, only 59¼ miles from the Marylebone terminus, is situated in a first-class hunting and residential district, and bids fair to become in the near future an important and favourite centre.

Taking a curve to the south-east, the line crosses a deep valley of the Bedfordshire Ouse, partly on embankments, and for 320 ft. by the Brackley Viaduct, which spans 62 ft. from the surface a large area of flood land.

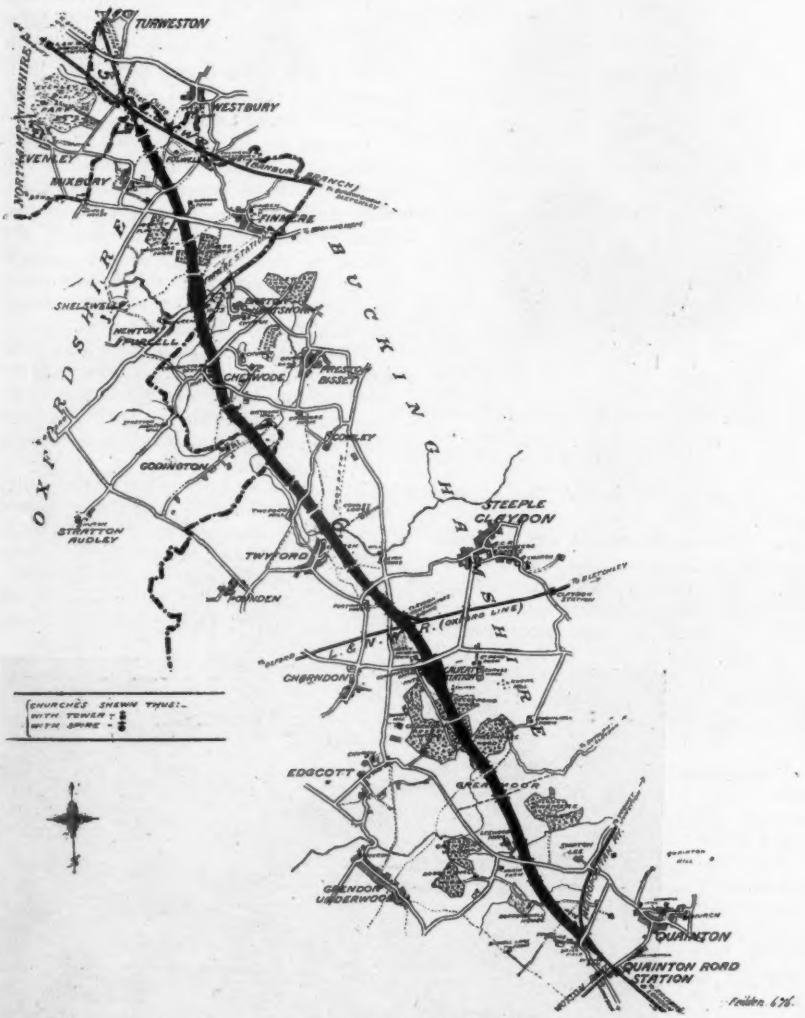
The design of this viaduct differs only from others on the southern section by the number of spans: arches, piers, and system of centering being the same. The Brackley Viaduct is 756 ft. long, and was originally designed for 22 spans, each of 34 ft. 3 in. The piers are tapered, and are 7 ft. 6 in. at the base and 5 ft. 3 in. at springing level. The foundations of the piers were carried down to a considerable depth below the surface level, where tough blue clay was met with.

Before deciding on the foundations, the engineers had borings on the site to test the nature of the material to be built upon; about 5 ft. below the alluvial deposit on the surface, the blue lias clay was met with, and as this continued for about 50 ft. in depth it was decided to remove about 10 ft. of it, and found the work on this clay, which was of a very tough nature.

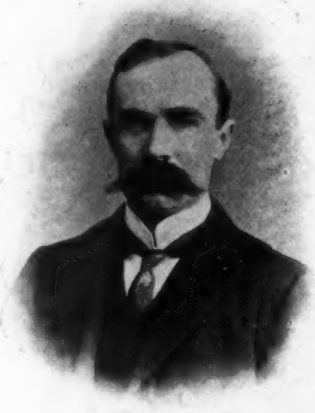
BRIDGE OVER BICESTER TO BUCKINGHAM ROAD.

To distribute the weight, a series of brickwork inverted ribs were built between the piers throughout the viaduct, except between the openings carrying the river and the mill-stream, which were inverted the full width of the piers.

It was afterwards decided to put in concrete toe walls at the north-east, south-east, and south-west corners, these walls being subsequently strengthened by heavy buttresses, some of which were carried



MAP OF CONTRACT NO. 6.



H. C. COLVIN SMITH, ESQ., A.M.I.C.E.
Resident Engineer, Banbury Branch.

more than 40 ft. below the original surface.

As before mentioned, it was originally intended to construct the whole of the viaduct with brick spans, but eventually two girder spans were introduced, consisting of steel-work plate girders, each about 35 ft. span.

On the north-east of the viaduct the piers supporting the metal superstructure were stayed underneath with arched struts consisting of steel-plate girders, horizontal on top, but curved on the bottom, so that the depth at the ends is 5 ft. 8 in., and in the centre 2 ft. $11\frac{3}{4}$ in. There is nowhere a greater pressure than two tons per square foot on the foundation.

The contractors' head local office for Contracts 5 and 6, and the Banbury Branch was located close to the south end of this viaduct, and here were built workshops, stables, and sleeping accommodation for 200 workmen.

Leaving the embankment the line enters a limestone cutting, which contained two or three beds of extreme hardness, which were utilised for concrete in the foundations of Brackley Viaduct. Nearly the whole of this cutting, with occasional firing to loosen rock ahead, was taken out by one of Ruston Proctor's steam navvies, which did excellent work.

Passing a single-arch skew segmental bridge of 33 ft. skew span, carrying the Buckingham to Brackley road, the railway crosses the main Bedfordshire Ouse Valley on a high embankment containing over 271,000 cubic yards.

The character of the clay in this valley was known from the experience gained during the construction of the Banbury branch of the London and North-Western Railway, which runs through it, and a lift of 15 ft. for the full width of the base was tipped of dry materials found

THROUGH FINMERE PLANTATION (LOOKING NORTH).

in adjacent cuttings, which prevented any spueing out when the top weight came on.

The Banbury branch of the London and North-Western Railway is crossed by an over-bridge, skew span 51 ft. and square span 26 ft., consisting of four plate girders, 58 ft. long, with a plate-girder parapet.

Ten chains further to the south a small under bridge is crossed, which is the last work on Contract No. 5.

CONTRACT NO. 6.

This contract commences with a cutting in clay, gravel, and soft limestone, and is spanned by two bridges.

Preliminary to the commencement of the operations a trial hole was sunk, which happened to hit a pot hole of clean gravel and sand, the only instance, with one or two insignificant exceptions, where any good gravel or sand were found on Contracts 5 and 6.

Continuing southwards a further cutting is crossed by a sunk road (Mixbury to Westbury) and by four other type bridges, one of which is a timber structure, with close-boarded parapets, carrying a bridle road for hunting convenience.

At the south end of the cutting the railway enters Finmere Station, of the country type, which is approached by an under-bridge, passing the Bicester to Buckingham Road under the railway. The bridge has a square span of 30 ft. and skew span of 36 ft., and is of the usual plate-girder type, shown very clearly in the illustration. The railway then enters on an embankment containing 200,000 cubic yards, tunnelled by three bridges, and continues into a cutting spanned by two public road and one accommodation bridge.

The line again passes over an embankment tunnelled by an occupation road under a bridge with Hobson's flooring,

JUNCTION WITH THE METROPOLITAN RAILWAY AT QUAINTON ROAD (LOOKING NORTH).

and the public road from Goddington to Buckingham.

The River Ouse threads this valley, and floods in every direction, necessitating three separate bridges of three, one and one opening respectively of 20 ft. spans each.

From this point to the junction with the Metropolitan Railway at Quainton Road, the works are of a light description, and call for no detailed attention. At 161 miles 41 chains from Manchester the railway passes the last bridge of the ordinary plate-girder and jack arch type,

and carrying the public road from Waddesdon to Quainton; and at 161 miles 49 chains the southern division terminates with a junction with the Aylesbury and Buckingham branch of the Metropolitan Railway.

The total quantity of excavation on the whole contract exceeds five million cubic yards out of 34 cuttings, the material being for the most part blue lias clay, though large quantities of limestone rock were also met with at Helmdon, Brackley, Mixbury, and Thorpe Mandeville. The largest cutting (at Thorpe Mandeville) contains 900,000 cubic yards of excavation, whilst there were several exceeding 500,000 cubic yards, and some of the embankments contained 800,000 cubic yards.

It is worthy of note that, throughout the whole of these cuttings, the slopes of which vary from 1 to 1 to 3 to 1, there were no serious slips, extensive precautionary methods of drainage having been adopted by the engineers.

There are 93 bridges, 35 of which are in brickwork, the steelwork of the remainder being executed by the Horsley Co., Ltd., Tipton.

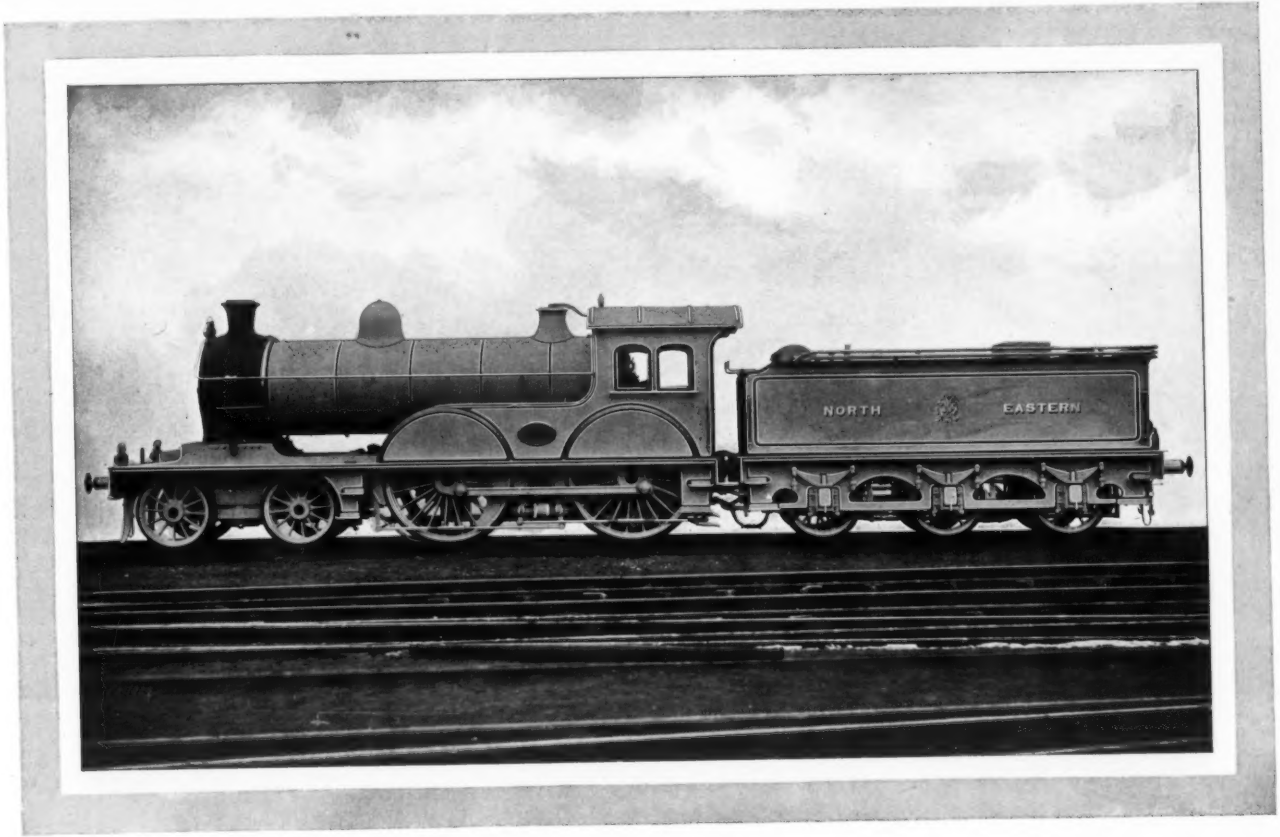
During the construction of the works about 2,500 men were engaged, in addition to which the contractors employed nine of the Ruston steam navvies, 18 locomotives, 700 earth wagons, and 120 trucks; and had laid down over 50 miles of temporary railways on overland routes, having five junctions with the existing lines.

The brickwork throughout the line is built with red bricks faced with Staffordshire brindles, a large portion of the former having been made at temporary brickworks situated at Sulgrave and Quainton Road.

(*To be continued.*)

BRACKLEY VIADUCT: THE LAST TWO BRICK ARCHES WHICH WERE CONVERTED INTO GIRDER SPANS.

SUP



NEW EXPRESS PASSENGER ENGINE, NORTH EASTERN RAILWAY.
Designed by MR. WILSON WORSDELL.

MACHINERY APPLIANCES AND PROCESSES

"Every part and side of our life, from the cradle to the grave, has been touched and tended by the inventor and manufacturer. His works are as numberless as the sands of the sea, but the onward rush of Science and the Arts opens up new fields of discovery and enterprise as each day dawns. Let us choose here and there among thousands, and in choosing take the best as far as in us lies."

NEW PASSENGER EXPRESS ENGINE.

NORTH-EASTERN RAILWAY.

THE subject of our special supplement this month is one of the latest express passenger engines, designed and built by Mr. Wilson Worsdell, locomotive, carriage and wagon superintendent of the North-Eastern Railway Company, to whom we are indebted for the photograph and following particulars.

This engine forms one of ten recently constructed at Gateshead, which are now hauling the heavy east coast express passenger trains between York and Edinburgh. As will be seen, they are of the four-wheel coupled type with a leading bogie, the diameter of the driving wheels being 6 ft. 10 in. The cylinders are 19 in. diameter, with a stroke of 26 in., and are fixed between the frames. The valves, which are of the piston type, are placed below the cylinders. The working pressure is 200 lbs. to the square inch, and the engines have made some very satisfactory performances, so much so that they are to be followed by twenty other engines of the same type. The following are some of the more important details :—

CYLINDERS.	Ft.	in.
Diameter of cylinders	0	19
Stroke of piston	0	26
Length of ports	1	$7\frac{3}{4}$
Width of ports	0	$1\frac{3}{8}$
Distance apart of cylinders, centre to centre	2	1
Distance between centres of valve spindles	0	12
Lap of valve	0	$1\frac{1}{8}$
Maximum travel of valve ...	0	$4\frac{11}{16}$
Lead of valve	0	$0\frac{1}{8}$
Stephenson's link motion ...		
Length of connecting rod between centres	6	8

WHEELS, STEEL.	Ft.	in.
Diameter of driving wheel ...	6	10
Diameter of trailing wheel ...	6	10
Diameter of bogie wheel ...	4	0
Thickness of all tires on tread...	0	3
Width of all tires on tread ...	0	$5\frac{1}{2}$
Distance between centre of bogie and centre of driving wheel	11	0
Centre of bogie wheels... ...	6	6
Centre of driving wheels to centre of trailing wheels ...	9	6
Distance from centre of driving wheel to front of fire-box ...	1	$10\frac{3}{4}$
Distance from centre of bogie to front buffer beam	6	1
Distance from centre of trailing wheels to back buffer plate ...	4	4

AXLES, STEEL.		
Diameter of wheel seat... ...	0	9
Diameter of bearings	0	8
Diameter of centre	0	$7\frac{3}{4}$
Diameter between centres of bearings	3	11
Length of wheel seat	0	$7\frac{7}{16}$
Length of bearings	0	9

BOGIE AXLE, STEEL.		
Diameter of wheel seat... ...	0	$7\frac{1}{2}$
Diameter of bearings	0	6
Diameter of centre	0	$5\frac{3}{4}$
Length of wheel seat	0	$7\frac{1}{4}$
Length of bearings	0	9
Distance between centres of bearings	3	7

FRAMES, STEEL.		
Distance between frames ...	4	0
Thickness of frames	0	1
Distance between bogie frames .	2	8
Thickness of bogie frames ...	0	$0\frac{3}{4}$

BOILER, STEEL.		
Centre of boiler from rail ...	8	4

BOILER, STEEL (*contd.*)	Ft.	in.
Length of barrel	11	6
Diameter of boiler (outside) ...	4	9
Thickness of plates	0	$0\frac{9}{16}$
FIRE-BOX, STEEL.		
Length outside	7	0
Breadth outside at bottom ...	3	11
Depth below centre line of boiler at front end	6	$0\frac{1}{2}$
Depth below centre line of boiler at back end	6	$0\frac{1}{2}$
Thickness of front plate ...	0	$0\frac{5}{8}$
Thickness of back plate ...	0	$0\frac{5}{8}$
Thickness of slides and top plate	0	$0\frac{5}{8}$
INSIDE FIRE-BOX, COPPER.		
Length at the bottom inside ...	6	$3\frac{1}{2}$
Breadth at the bottom inside ...	3	$2\frac{5}{8}$
From top of box to inside shell...	1	$4\frac{15}{16}$
Depth of box inside at front ...	6	$11\frac{1}{2}$
Depth of box inside at back ...	6	$11\frac{1}{2}$
TUBES, STEEL.		
Number of tubes... ... 255		
Length of tubes between tube plates	11	$10\frac{1}{8}$
Diameter outside	0	$1\frac{3}{4}$
Diameter of exhaust pipe nozzle	0	5
Height of chimney from rail ...	13	1
Heating surface :		
In tubes ... 1,383 sq. ft.		
In fire-box ... 144 „		
Total ... 1,527		
Area of fire-grate ... 20		

WEIGHT OF ENGINE IN WORKING ORDER.	Ton.	cwt.
On bogie wheels...	16	9
On driving wheels	19	13
On trailing wheels	15	12
Total...	51	14

WEIGHT OF TENDER IN WORKING ORDER.		
On front wheels	13	6
On middle wheels	11	6
On trailing wheels	13	6
Total	37	18

TENDER.

WHEEL BASE.	Ft.	in.
From front buffer beam to centre of leading wheels	4	2
From centre of leading wheels to centre of middle wheels ...	6	4
From centre of middle wheels to centre of trailing wheels ...	6	4
From centre of trailing wheels to back buffer beam	4	5

WHEELS, STEEL.	Ft.	in.
Diameter of wheels on tread ...	4	0
Thickness of tyres	0	3
FRAMES, STEEL.		
Distance between inside frames.	4	1
Thickness of inside frames ...	0	$0\frac{1}{2}$
Distance between outside frames	6	$2\frac{3}{4}$
Thickness of outside frames ...	0	$0\frac{7}{8}$
Capacity of tank ... 3,375 gall.		
Capacity of well ... 162 „		
Total... ... 3,537		
Coal space ... 5 ton.		

This tender is also fitted with a water scoop.

H.M.S. "PEGASUS" AND "PYRAMUS."

IN our last issue we gave a few preliminary details of these two new third-class cruisers belonging to a class consisting of eleven vessels, of which the *Pelorus* was the first. We are now able to give an illustration of H.M.S. *Pegasus*, the noteworthy feature in connection with which is that this is the first vessel of large dimensions in which the Admiralty have decided to adopt express or small-tube boilers. The principal dimensions of the vessel are as follows :

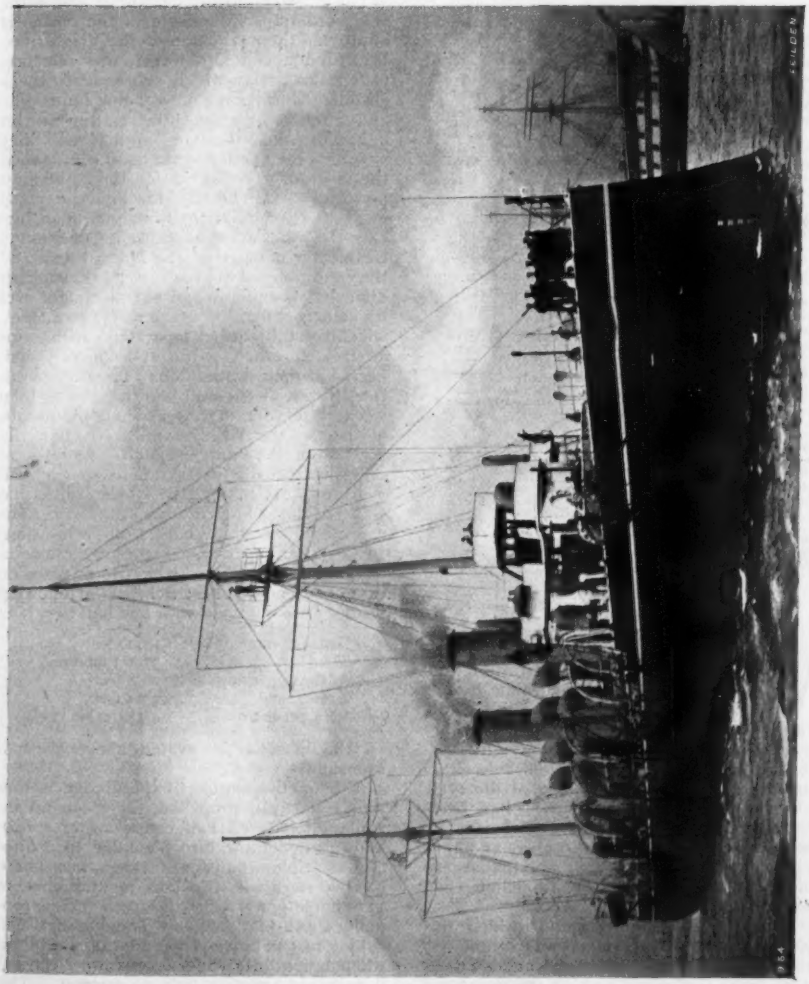
Length between perpendiculars	300 ft.
Breadth extreme	30 ft. 6 in.
Depth, moulded	21 ft. 2 in.
Displacement	2135 tons.
Indicated horse-power	7000

The displacement given above is upon the basis of a mean draft of 13 ft. 6 in., but the maximum draft is 17 ft. The vessel is expected to attain a speed of 20 knots. The hull throughout is built of steel, and a sloping protective deck, formed of two thicknesses of plating and situated 2 ft. 6 in. below the load water-line, extends over the whole length.

The propelling machinery consists of two sets of vertical triple-expansion engines fed with steam by eight Reed water-tube boilers. The working pressure of the boilers is 300 lb., while that at the engines is 250 lb. The number of revolutions per minute is 220, a comparatively high speed. The diameters of the cylinders, of which each set of engines has three, are as follows : high-pressure $20\frac{1}{2}$ in., intermediate 33 in., low-pressure 54 in., the stroke being 27 in.

The armament consists of eight 4-in. and eight 3-pounder quick-firing guns. There are also three ·45 Maxim guns and two 14-in. torpedo tubes on the upper deck, one on each broadside.

The steam trials of both vessels were eminently successful, in the case of the *Pegasus* being the shortest on record, with the lowest coal consumption of her class. Both trials are reported as follows :



H.M.S. "PEGASUS," CONSTRUCTED BY PALMER'S SHIPBUILDING AND IRON CO. LTD., JARROW-ON-TYNE.

H.M.S. "Pegasus."

		30 Hours' Consumption Trial at 3500 Indicated Horse-Power.	8 Hours' at 5000 Indicated Horse-Power.	4 Hours' Full Power Trial at 7000 Indicated Horse-Power.
Draught of water	Forward ..	11 ft. 8 in.	10 ft. 10 in.	10 ft. 4 in.
	Aft ..	15 ,, 7 ,,	15 ,, 2 ,,	14 ,, 10 ,,
	Midships ..	13 ,, 7½ ,,	13 ,, 0 ,,	12 ,, 7 ,,
Pressure in Boilers lbs.		261	278	255
Revolutions per minute		176.4	203.25	217.75
Vacuum in condensers ..		26.2	25.9	25.15
Indicated horse-power.	High ..	1190	1603	2277
	Intermediate	1274	1900	2491
	Low	1234	1897	2359
Total indicated horse-power		3698	5400	7127
Air pressure in stokehold in.		.4	.86	2.44
Consumption of coal per indicated horse-power per hour.. .. lb.		1.96	Not taken	Not taken
Speed of vessel .. knots		17.26	20.0	21.2

H.M.S. "Pyramus."

Draught of water	Forward ..	12 ft. 9½ in.	12 ft. 0 in.	12 ft. 0 in.
	Aft	15 ,, 7½ ,,	15 ,, 4 ,,	15 ,, 3 ,,
	Midships ..	14 ,, 2½ ,,	13 ,, 8 ,,	13 ,, 7½ ,,
Pressure in boilers lbs.		245	247	261
Revolutions per minute..		176.5	205.05	220.3
Vacuum in condensers ..		27.2	27.25	26.15
Indicated horse-power	High ..	1066	1587	2250
	Intermediate	1231	1897	2367
	Low	1298	1940	2486
Total indicated horse-power...		3065	5424	7303
Air-pressure in stokehold in.		.8	1.36	2.5
Consumption of coal per indicated horse-power per hour.. .. lbs.		2.05	Not taken	Not taken
Speed of vessels .. knots		17.49	19.9	20.7

NEW HYDRAULIC DREDGE.

We are able to give an illustration and some particulars of a hydraulic dredge of the type designed by Mr. Lindon Bates in connection with the important engineering works in contemplation at Antwerp. During the preliminaries indispensable to so great an undertaking, a dredge of the type intended for the River Scheldt has been completed for the Russian Government to be utilised in dredging the Volga, and this represents what is claimed to be the largest and most powerful dredging machine ever constructed.

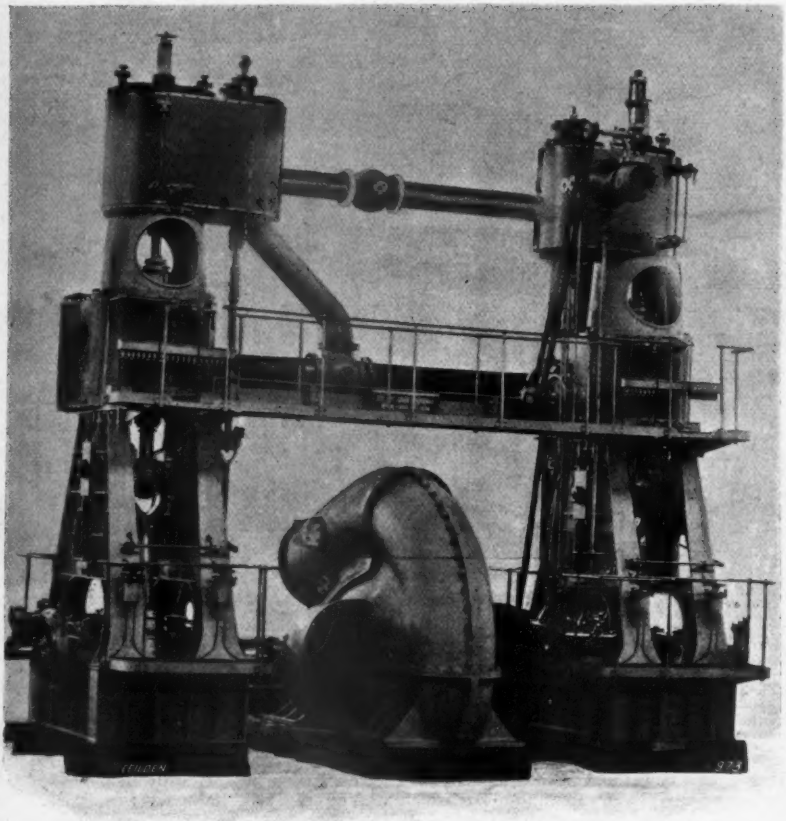
The system of dredging for which the dredge has been constructed was originated by Mr. Lindon Bates in the United States some years ago, when he built the prototype of this design of craft—the *Beta*—for the American Government. The output contracted for was 1,600 cubic yards; but in the official trials the dredge proved far in advance of the estimates, reaching the almost incredible record of 7,800 cubic yards an hour. A performance so remarkable naturally created widespread attention, and led to the consultation of Mr. Lindon Bates by a large number of Governments and important municipalities.

The Russian Government were first in the field, ordering a duplicate of the *Beta*, for improving the navigation of the Volga river. Mr. Lindon Bates, however, was reluctant to repeat a design which subsequent experience had shown capable of being improved; and after representing the matter in this light to the Russian authorities, they amended their order so far as to commission the inventor to construct for them the most powerful and effective machine he could evolve. No limitations were put upon him save the necessity of adapting his creation to the narrow passage of the Marie Canal and the conditions of the river itself. The former difficulty was simply and effectively got over by constructing the dredge in two halves, which could be towed separately, or in a line after each other, to be subsequently connected at their destination. The dredge was constructed by the well-known Société John Cockerill of Seraing, Liège, and represents, of course, the largest and most powerful creation of the kind ever built. As we have said, it is made in two parts, each half measuring 216 ft. long by 31½ ft. wide, and 9 ft. deep. The dredge can either be operated in separate halves, or as a whole. In the latter capacity, it makes a bottom cut 62 ft. wide. At a trial which took place on the upper reaches of the Scheldt the following results were obtained with one half:

Distance run . . .	1,000 feet
Time	37-1/3 minutes
Advance per minute .	26·8 feet
Average cut . . .	2·44 feet
Rate per hour . . .	4,524 cubic yards

Of the material excavated about one-half was sand.

A distinctive feature of the dredge is that it is electrically propelled, the electrical installation of each half consisting of a 600-kilowatt generator, direct-coupled to a fore-and-aft triple-expansion steam engine. There are two stern and two bow motors, each of 125 horse-power, driving twin screw-propellors, 4 ft. in diameter. The dynamos also supply two 30 horse-power motors controlling the pontoon line, while a separate electrical installation supplies lighting current. The dominating idea has been to place the entire control of all the operations in connection with the work or dredger in one central

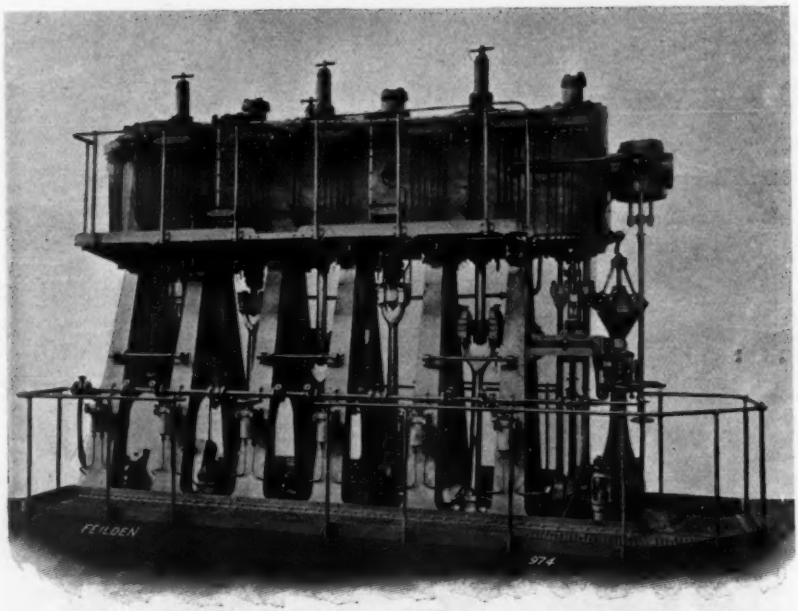


NEW HYDRAULIC DREDGE: MAIN PUMPING ENGINE.

position, which is situated in the pilot-house; all the switches, rheostats, controllers, and compensators being within easy reach of a single operator. Three-phase current is employed, being found to have several advantages over direct, permitting lighter machinery and more economical maintenance. The generators are 550 volts, 24-pole, driven by an 800 horse-power marine engine, running at 200 revolutions, giving a frequency of 40 periods per second. The entire electric plant was constructed by the General Electric Company, of Schenectady, U.S.A.

The Lindon-Bates dredge is on the principle of the suction-dredge, whose value for both rough and smooth-water uses has long been established. The Bates system, however, undertakes work on a scale that has never before been attempted; and it is probable that it is destined to be instrumental in effecting great results in the promotion of trade, and navigation in places where natural obstacles have hitherto proved an insuperable difficulty. Several of the ports in South Africa, for instance, notably East London and Algoa Bay, have been severely handicapped by the sand-bars which steadily accumulate at the harbour-entrances. Effective dredging would ensure a great sav ng in transhipment, by allowing vessels of heavy draught to approach so near to the port as to land direct in docks.

The excavation of the Lindon-Bates dredge



NEW HYDRAULIC DREDGE: MAIN ELECTRIC ENGINE.

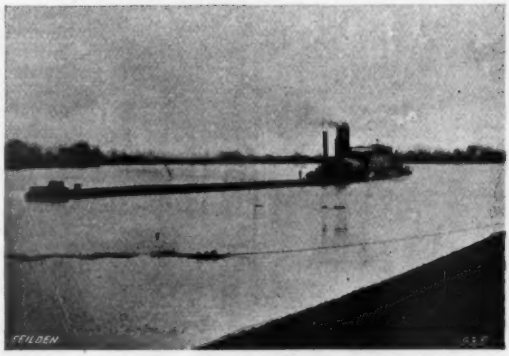
as carried out in his Volga construction is effected by eight cutters, four on each division, forming a complete structure, which can be raised or lowered to any desired depth to 16 ft. An arrangement of suction-pipes, leading to a powerful centrifugal pump, removes the mixture of water and *débris*, which is conveyed through pipes mounted on pontoons and discharged. The cutters are driven by a steam-engine situated in the forward part of the hull. The centrifugal pump is driven by a divided vertical triple-expansion engine, with an indicated horse-power, varying from 1,425 to 1,600.

VIEW OF HALF OF THE DREDGE, LOOKING ON THE STARBOARD QUARTER.

Steam is provided by eight Babcock-Wilcox water-tube boilers, four being situated in each half hull. The boilers are fired exclusively with naphtha, and altogether this plant has given the greatest satisfaction. On the occasion of trials which took place last year, these boilers worked throughout without a hitch, giving an abundance of perfectly dry steam at full power. No trouble was experienced at any time in obtaining a sufficiency of steam, although the boilers were working at a very high rate of evaporation, estimated at nearly eight pounds of water per square foot of heating surface per hour.

Mr. Lindon Bates, in our judg-

ment, is entitled to praise, not only for the great enterprise and mechanical genius he has manifested in the design and construction of a plant which in some respects must be considered as almost revolutionary, but for the beneficial effects which it appears destined to accomplish in the promotion of the world's trade and industry.



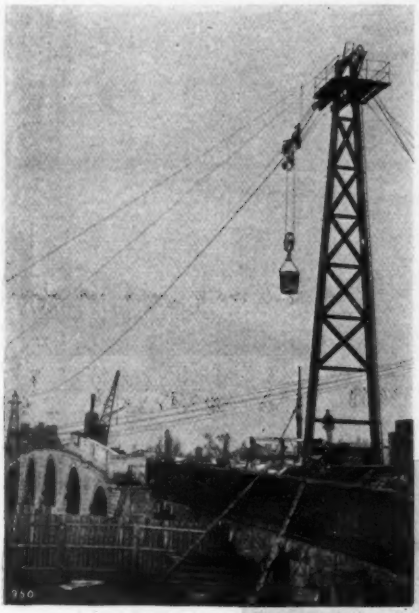
VIEW OF ONE HALF OF DREDGE AND DISCHARGE PONTOON LINE.

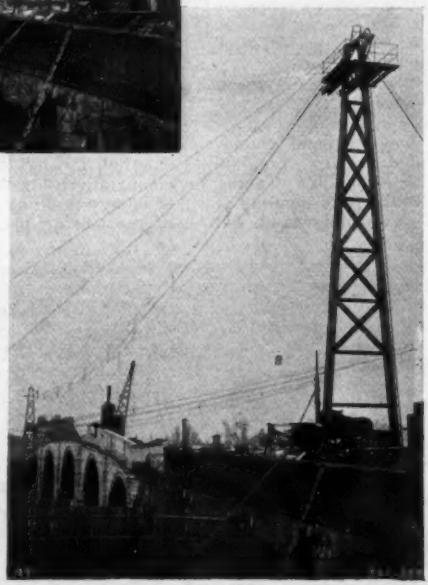
CABLEWAYS AND THE REBUILDING OF THE KEW BRIDGE.

SOME little time ago (December, 1899) we referred to the cable conveyors and the hoists designed by Mr. John M. Henderson, of Aberdeen, which have been in extensive employment in London and elsewhere. By the courtesy of Mr. Henderson we are enabled to present some illustrations showing the application of the cable system of transporting materials to the demolition and rebuilding of the new bridge at Kew, London, contracted for by Mr. Easton Gibb. Taking the two operations together, the quantity of material to be handled, we understand, will not be less than 40,000 tons. The system has been in operation about two months, and, as will be observed from the photograph, the major part of the superstructure of the old bridge has been stripped.

A few observations on the cableway system may be useful in the present connection. It is possessed of several very important advantages over other means of shifting material, among the chief of which is its comparatively low initial cost. The reduction of energy resulting from economy in weight of the moving plant is, in the case of the

GENERAL VIEW OF THE CABLEWAY AT KEW BRIDGE.





OTHER VIEWS OF THE CABLEWAY SHOWING THE METHOD OF OPERATION.

cableway, estimated as at some fifteen to one.

Cableway transport takes the place of cranes carried on stagings or gantrys posted up and strutted from the river bed. The waterway is thus left free of obstruction to floating craft, instead of encumbering the river with a maze of piles, as in the ordinary course. No costly stages are required to be erected, and the hoisting and transporting arrangements are unaffected by flood or collision. Apart from this, which is only concerned with local and therefore varying circumstances, the cableway presents the following advantages over the travelling crane heretofore chiefly employed:

As against, say, a five-ton load by means of an overhead traveller weighing with its boiler some 27 or 30 tons, the cableway will hoist and transport equally heavy loads, the weight of the moving apparatus in the latter case, however, being only 8¾ cwts. Furthermore, the most smartly worked crane would have a hoisting speed not exceeding at the utmost 75 ft. per minute, whilst the cableway hoists an equal load at the rate of 275 ft. in the same time. As compared with the travelling crane the advantages of cableway are similarly evident; since, while the travelling crane may run the load at possibly 150 ft. per minute, the cableway can travel easily at five times this speed, that is to say, at about 8 miles an hour.

The cableway installation at Kew takes 550 ft. span, the supports on the north and south banks being 50 ft. and 60 ft. high respectively. The operator's platform is so situated that he commands a full view of the work from end to end. The engines are of the double cylinder type, 10 in. diameter, and 18-in. stroke. The winding drum and travelling wheel is 5 ft. 6 in. diameter. All the controlling levers are brought to one point on the operating platform, the machine handling a load of five tons at a time.

A complete electrical signalling apparatus has been installed in connection with the works by which every direction, however minute, connected with the working of the cableway can be conveyed from every part of the bridge. The apparatus is intended for night work and foggy weather. The installation, as a whole, has afforded the greatest satisfaction, and, as an object-lesson of up-to-date engineering, is likely to be followed by consequences of a highly satisfactory nature to its maker. At the works at Aberdeen orders, indeed, are in hand for plant which, when completed, will be capable of dealing with an

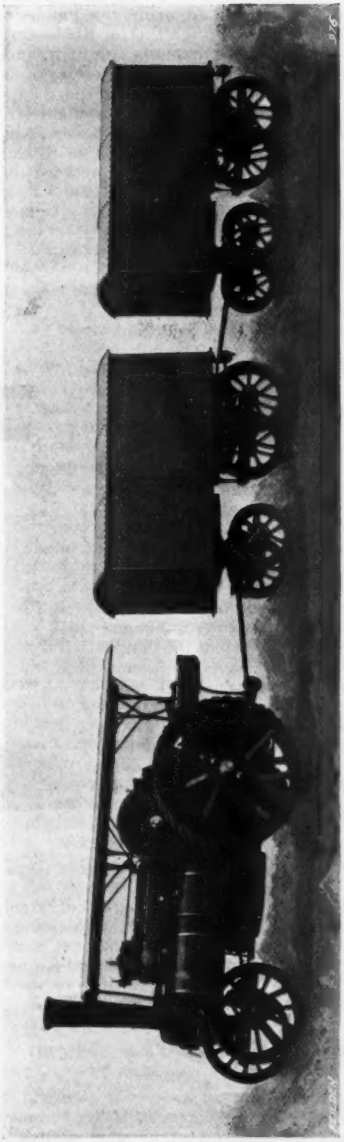
aggregate of all kinds of materials of about 4,500 tons per working hour. The cableway is being used now for many different classes of work, and is employed for H.M. Government for dock excavation.

WAR ROAD LOCOMOTIVE.

It has been recognised from the first by our military authorities that the greatest difficulty our troops will encounter on their advance, will be adequate transport for the colossal stores they will be required to carry with them. Apart from the character of a large part of South African territory where, in many districts, forage is difficult to obtain, epidemics of a most serious nature are liable to arise among the horses, mules and oxen customarily used for transport purposes, and, whether these are likely to occur or not, their liability to do so involves in great risks the armies whose available munitions and commissariat depend on animal transportation

In these circumstances, it was inevitable that mechanical traction should be considered in connection with the transportation of army supplies over large stretches of arid country. Though it may be a matter of surprise that larger use has not been made of traction-engines for this and similar uses than has yet been the case in South Africa, it is satisfactory to note that at least a start has been made and that the engines on the spot have, so far, acquitted themselves in every way correspondent with expectations formed of them. Thus, the other day, we read of a team of 32 oxen labouring for hours unsuccessfully to extricate their load from a hole in a "drift"; and of a steam traction-engine being hitched on, which, forthwith drew the whole complement, waggon, oxen and all, free of the impediment and up the adjoining hill without the least difficulty. Considering that coal and water are the only supplies that a traction-engine requires, and that it can carry enough of these to supply itself over an infinitely wider range than animals their forage, it is, we repeat somewhat surprising that use has not been made of the traction-engine on a larger scale than appears to have been the case; more especially when we consider that the average rate of progress made by oxen teams does not, under the most favourable circumstances, attain more than fifteen miles a day.

In this connection, we are pleased to



SPECIAL TYPE OF ROAD LOCOMOTIVE, DESIGNED FOR AND SUPPLIED TO H.M. WAR OFFICE BY MESSRS. AVELING AND PORTER, ROCHESTER.

illustrate and give some particulars of a special type of Road Locomotive, designed for and supplied to H.M. War Office by that well-known firm of road locomotive builders, Messrs. Aveling & Porter, Ltd., of Rochester. The locomotive is compound, with high- and low-pressure cylinders, side by side, of a diameter of 7½ in. and 12 in. respectively. The crank is double throw, 4-in. diameter, cut from the solid ingot. The boiler is of mild steel hydraulic tested to 300 lb. to the square inch for a working pressure of 150 lb. The grate area is 7 square feet, affording a heating surface of 194·54 square feet. Wheels are of wrought iron specially strengthened, the driving wheels being 7 ft. 6 in. diameter by 2 ft. wide, and front wheels 4 ft. 6 in. diameter and 1 ft. wide. The water tanks have a capacity of 409 gallons, and there are an extra large coal bunker, a special brake acting on insides of the rims of both driving wheels, a double water elevator for lifting and forcing with hoses, a governor to enable the engine to drive a dynamo searchlight, &c. There are also a winding drum with 750 ft. of steel wire-rope and a large number of other special appliances. The engine indicates 75 horse-power, and is speeded at three and six miles per hour. From a perusal of the foregoing, it is evident the details of this engine have been most carefully worked out with reference to the varied objects to which it may be applied at the place of its destination, and that it must of necessity prove a most valuable accessory to the British forces

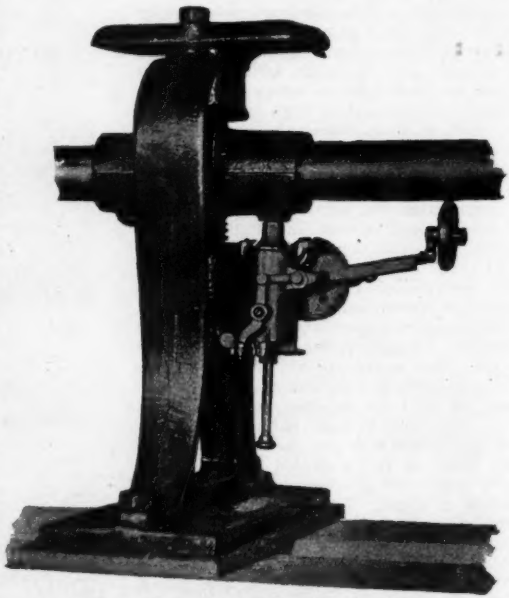
Special traction waggons have also been designed by Messrs. Aveling & Porter, constructed of mild steel and wrought iron throughout, the under-carriages of steel, mounted on strong laminated steel springs, the wheels being of wrought iron 1 ft. wide, plated up with extra tyres. The whole are plated with ⅜ in. steel for carrying ammunition with sliding doors.

The attention of Foremen, Under-Foremen and Mechanics is invited to the "Workshop Practice" section of FEILDEN'S MAGAZINE.

AUTOMATIC LUBRICATOR.

We illustrate an ingenious device for the employment of cylinder oils and similar lubricants for ordinary shaft and crank bearings.

The working of the apparatus may be readily understood by a reference to the illustration. An eccentric worked from the shaft actuates a rack gearing, by which the flow of lubricant is regulated automatically by the speed, the lubricant being forced by the pressure of an interior piston on to the bearings. It is claimed that its use effects a considerable saving in the cost of lubricant; that it is constant and invariable in its action, and can be filled without detachment from the bearing.



NEW AUTOMATIC LUBRICATOR.

When the lubricator is to be used for crank bearings, the wheel is exchanged for a small cast-iron ball and the arm held in a vertical position by a spring. The feed motion is therefore obtained through the alternate action of the spring and the centrifugal force giving the arm a reciprocal motion.

"THE STORY OF SMOKELESS POWDER."

It will be remembered that attention was drawn in this magazine some time ago to an article published in an American contemporary on the subject of smokeless powder. As an historical survey of the development of this explosive the article purported to be complete, and was not, as far as it went, uninteresting. The most conspicuous feature about it, however, was the omission of one of the best known names in connection with smokeless powder, namely, that of Mr. Hiram Stevens Maxim. This omission despoiled the claims of the article to be considered complete, and led up to the criticism before mentioned.

MR. HIRAM STEVENS MAXIM.

In due course, and as an outcome of this criticism, the author, Mr. Hudson Maxim, sent over from America a mass of data, chiefly in the shape of contributed articles from his own pen, bearing upon the question accompanying this with the request that we should properly investigate the matter and do him justice by expressing the results of our researches in these columns.

Some time had necessarily to elapse before any finality could be reached in investigations which involved the expenditure of a large amount of time and trouble, chiefly, in connection with a research in the Patent Records of this country; an investigation cheerfully undertaken as a duty where an important distinction between patents bearing the same name had to be made, to prevent the serious error arising of crediting the wrong man with meritorious discoveries. The moment has now arrived when we can enter somewhat into detail with regard to the claims of Mr. Hiram Stevens Maxim—the name singularly omitted in the article under consideration—as a pioneer in the manufacture of smokeless powder.

Without traversing in too detailed a fashion the early history of smokeless powder it may be mentioned that Braconnot, in 1833, investigated the action of nitric acid on starch, with the result that a rapidly burning body was produced which he termed xyloïdine. This substance was further investigated by Pelouze in 1838, but Schönbein is generally credited with the discovery of gun-cotton in 1846, although it appears to have been almost simultaneously discovered by Böttger and by Otto. The investigations of Knop, Kamarsch, Heeren, Millon and Gaudin in 1847 are important in that they determined various methods of producing nitro-celluloses, as gun-cottons or pyroxylines are generally termed, although chemically speaking, it would perhaps be more accurate to describe them as cellulose nitrates.

It is important that the distinction which exists between these cellulose nitrates be well-defined, as the loose terminology employed when dealing with these, by patentees, gave rise to some misunderstandings and even litigation.

The series of nitro-celluloses, while possessing many properties in common, are sufficiently well characterised, and the following are known:

Gun-cotton or Cellulose hexa-nitrate.

$$C_{12}H_{14}O_4(NO_3)_6$$

Insoluble in alcohol, ether, or mixtures of both, in glacial acetic acid or methyl alcohol, slowly soluble in acetone.

Cellulose penta-nitrate.

$$C_{12}H_{15}O_5(NO_3)_5$$

Insoluble in alcohol, soluble in a mixture of ether and alcohol.

Cellulose tetra- and tri-nitrates.—The compounds generally known as collodion pyroxyline are formed together, and it is not possible to separate them.

Soluble in a mixture of ether and alcohol, acetic ether and acetic acid.

Cellulose di-nitrate.

$$C_{12}\,H_{18}\,O_8\,(NO_3)_2$$

Very soluble in a mixture of ether and alcohol, and in absolute alcohol.

The essential feature of these nitro-celluloses is that it is difficult to isolate any one of them in a state of purity, as the degree of nitration is dependent upon conditions which lead to the simultaneous formation of both higher and lower nitrated bodies.

The manufacture of explosives containing as an essential factor nitro-cellulose received a great impetus when in 1875 Nobel took out a patent for the manufacture of blasting gelatine, and by using a mixture, di-nitro-cellulose and nitro-glycerine, started the series of gelatinised cellulose, the manufacture of which now forms the basis of an enormous industry.

Nobel's compound, however, was perhaps limited in scope, in that the combustion was not under perfect control, and, therefore, was not capable of being utilised as a propulsive explosive, although it is probable Nobel realised that plastic mixtures of different consistencies were obtainable.

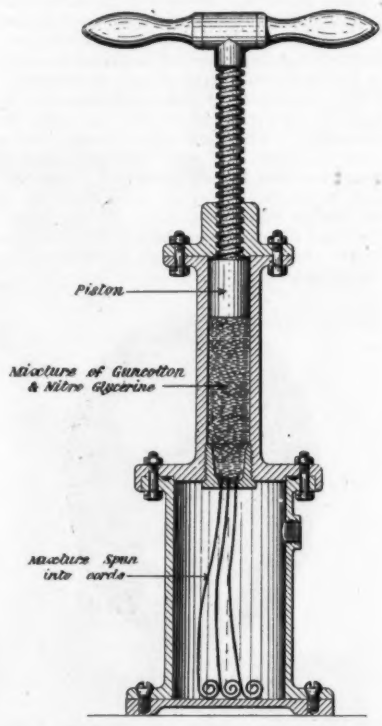
In 1887, Mr. *Hiram* S. Maxim, actuated by a desire to produce a high explosive, in which the combustion was more under control, and which would consequently be available as a propulsive explosive for use in artillery, took out a patent for the treatment of a compound of nitro-glycerine and gun-cotton. This patent was numbered 2628, and applied for on February 19th, and accepted on December 20th 1887, in which, on page 4, occurs the following paragraph :

> "Blasting gelatine (which consists of *gun-cotton dissolved in nitro-glycerine*) is advantageously treated for the purpose of my invention, while in the course of manufacture, as hereinafter described, that is to say, I exclude air therefrom by *mixing, or incorporating, the gun-cotton and nitro-glycerine* in a vacuum, or partial vacuum. In some instances I carry on one or more of the latter steps or stages in the manufacture of the explosive compounds, either in a vacuum or partial vacuum, or under water, according to the nature of the ingredients employed."

In passing, we may mention that patent No. 2628/87 is interesting also in that it seems to be the first patent in which mention s made of spinning the explosive compound into threads or cords by forcing it through holes under pressure, a proceeding similar to that which later suggested the name of "cordite."

In this patent the quantity of nitrated cotton was much greater than in blasting gelatine, the resultant material being of so close a consistency as to enable it to be spun.

In 1888 Nobel took out his Ballistite Patent in which a still larger percentage of gun-cotton was used, the patent expressly stipulating that the soluble variety of nitrated cotton should be used, that is di-nitro-cellulose. To distinguish this from Mr. Hiram Maxim's patent, the compound was described as a



This illustrates the apparatus employed by Mr. Hiram S. Maxim in making the first cordite ever produced. The apparatus was originally constructed for the treatment of compounds of nitro-glycerine and gun-cotton. Mr. Hiram S. Maxim's Brit. Pat. No. 2628, dated February 19th, 1887, from which this illustration was made, describes a material consisting of gun-cotton dissolved in nitro-glycerine, and distinctly states that the material was formed into threads or strips by being forced through holes by a screw piston. A considerable quantity of cordite was made with this apparatus from a very stiff and rough compound referred to as gun-cotton dissolved in nitro-glycerine and, curiously enough, the diameter of the threads were the same as the British rifle cordite of to-day. The compound employed has sufficient cotton added to make it as stiff as could be made and still be spun into threads. The experiments were conducted in Ardare, Scotland.

This patent is important in view of the statement made by Mr. Hudson Maxim that Mr. Hiram Maxim never thought of using gun-cotton and nitro-glycerine till 1889, which would be contemporary with his own alleged discoveries.

"propellant" in contradistinction to an "explosive." This was the celebrated Nobel patent which was contested in the cordite case in which Nobel sued the Government, and in which it was proved that neither his 1888 powder nor his previous powders did contain true gun-cotton of the insoluble kind, and that he had sought to tame nitro-glycerine by adding a sluggish explosive, *i.e.*, di-nitro-cellulose, which is a totally different substance from tri-nitro-cellulose, which is the modern technical term for true gun-cotton of the highly nitrated variety.

Later in 1888 Mr. *Hiram* S. Maxim took out a patent which contained not only nitro-glycerine but also a highly nitrated variety of gun-cotton. The patent was numbered 16,213, 1888, and on page 1 reads as follows:

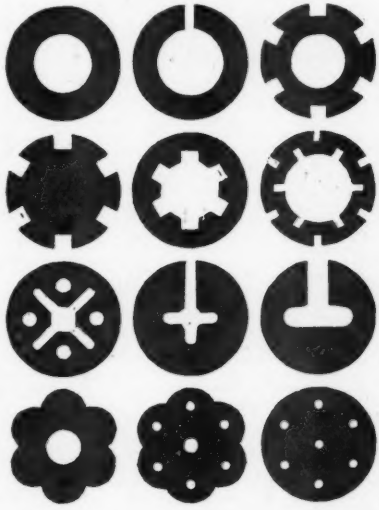
> "Attempts have heretofore been made to manufacture explosives from collodion formed by the treatment of the low grades of gun-cotton. By the low grades, I mean those which are readily soluble in ether or alcohol, or in a mixture of these substances, and which do not contain a large percentage of oxygen. The low grades of gun-cotton are unstable, do not withstand the action of sunlight, and, as they do not contain sufficient oxygen to consume all the vegetable matter of which they are composed *they produce, in burning, a large quantity of smoke.*
>
> "My invention relates chiefly to the manufacture of pellets, grains, or other forms of powder, or explosive material, from the higher grades of gun-cotton, that is to say, the highly explosive grades thereof, which are *not soluble in ether or alcohol.* To accomplish this result I soften, or dissolve, the gun-cotton in acetone, either alone or mixed with ether or alcohol, or in ethylic acetate, or in similar liquids. I am thus enabled, without the use of any of the low grades of gun-cotton, to make highly explosive material, which produces *a very small proportion of smoke*, and which has great stability."

It was in the year 1888 that the author of the monograph in *Cassier's Magazine* states that he began the experiments in England which ultimately led to his inventing, with the collaboration of another investigator, a smokeless powder which was tried by the United States Government at Sandy Hook with such disastrous effects.

This statement is somewhat singular, to say the least, when it is known that on the occasion when the merits of the various inventors of smokeless powder were fully discussed, *i.e.*, during the two great cordite cases in England, the name of the man he he ignores, viz., Mr. Hiram S. Maxim, was conspicuously brought to public notice. During these great patent trials it was demonstrated that the British Government powder was a compound of true, or insoluble, gun-cotton and nitro-glycerine, and that Mr. Hiram S. Maxim was undoubtedly the pioneer in compounding a combination resembling the Government powder, and containing true, *i.e.*, insoluble gun-cotton.

Mr. Hiram S. Maxim's merits, as we have already mentioned, were most strongly endorsed by the Attorney-General, Sir Richard Webster, in the case of *Nobel* v. *Anderson*, but we will quote from the official report of that case under the date of February 7th, 1894, the following:

> *The Attorney-General.*—" . . . Maxim's patent is important for this reason, merely as a part of the history of the case. Whereas up to that time there had been a studious exclusion of the gun-cotton of the *insoluble form, Maxim is the first person who includes it. He is the first person who purports to deal with it.* . . ."*



The above illustrations are very interesting and important, inasmuch as they clearly show how slight a change in inventions previously taken out by his brother, Mr. Hudson Maxim considers necessary to entitle him to considerations as an inventor. The above figures, from 1 to 11, are accurately copied from Mr. Hiram S. Maxim's British Patent, specification No. 1794, dated September 21st, 1894.

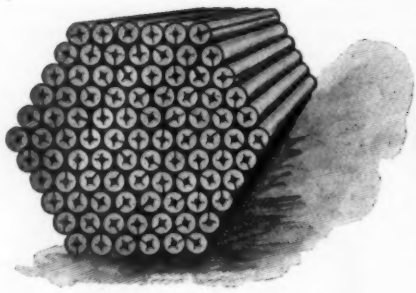
The inventor states that he does not confine himself to the forms shown, and that these forms are only given as examples. The object of the invention is to provide air spaces, or internal cavities, into which the flame may enter.

When the plastic compound from which smokeless powder is formed is forced through a die it naturally takes the form of the hole in the die, but according to Mr. Hudson Maxim's way of thinking Mr. Hiram S. Maxim failed to patent the hole, so we find that about eight months later Mr. Hudson Maxim patented the hole, and still later he patented the form of powder marked 12.

And later:

> "I use this, my Lord, for the purpose of emphasising the fact that *Maxim was the first to introduce the suggestion of the insoluble gun-cotton*; that Mr. Nobel in the experiments that he was contemplating right through 1888, through 1889, and up to 1890, as far as he was concerned, *was always sticking to the soluble form.*"

* The italics are ours.

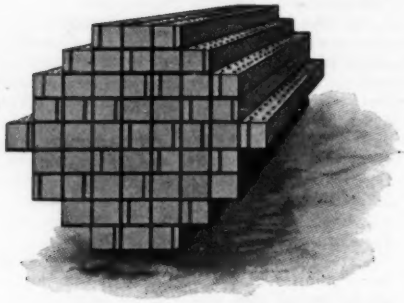


When smokeless powder is provided with internal holes or cavities, such as, for example, the multiple perforated variety, it is necessary to cut it into short lengths, otherwise it will be blown to pieces in the bore of the gun and cause high and dangerous pressures.

It is, however, advantageous to employ powder cut nearly equal to the length of the powder chamber of the gun, and in such cases it is necessary to allow the flame to enter and the gases to escape at the side of the rods instead of at the ends only.

The above shows one of three forms patented by Mr. Hiram S. Maxim—British Patent No. 17,994, dated September 21, 1894.

This is believed to be the first patent ever granted for a powder formed into long sticks or rods with internal cavities so arranged that the flame may enter at the side. The system also has other advantages; the inventor, in his patent, stating: "I prevent in a great measure the wave action of the violent to and fro movement of the explosive during firing, which action or movement is sometimes set up in the discharge of large cartridge cases."



Mr. Hudson Maxim, recognising the advantages of internal cavities, and of making the sticks the full length of the powder chamber, patented the above form, and he claims for it the exact advantages set forth in the original patent. It would therefore appear that all of the supposed novelty and advantages claimed by Mr. Hudson Maxim were fully anticipated in the earlier patent of his brother.

From this it will be apparent that to leave out, in a history of smokeless powder, the name of the man who first invented the compound that is the basis of cordite is absurd.

Early in 1889, Mr. *Hiram* S. Maxim took out a patent for a compound composed of nitro-glycerine, gun-cotton and castor-oil, the addition of the latter being made as a preservative, as it was found that the powder previously made became opaque and fibrous upon keeping, owing to the evaporation of the solvent, and burnt with great violence. The addition, however, of about 2 per cent. of castor oil removed the difficulty.

As a result of independent investigations, Sir Frederick Abel and Professor Dewar patented, fourteen days later, a similar compound.

Another "cordite" case followed with Mr. Hiram Maxim against the Government. The latter sought, in the first instance, to call into question the validity of the patent and the utility of the process, but at the commencement of the trial both points were admitted; but counsel for the Government claimed that no infringement had taken place because the Maxim patent was for a compound consisting essentially of gun-cotton (containing over 80 per cent.), whereas the Government cordite was essentially a nitro-glycerine powder containing 68 per cent. of nitro-glycerine.

The fact that Mr. Hiram S. Maxim used castor oil and claimed other suitable oils in his patent was admitted as a novelty, but the Government claimed that no infringement had taken place when they used cylinder oil under the name of mineral jelly, which was in reality a hydrocarbon and not an oil at all. Therefore the court decided that the patent, though good, had not been infringed.

The next step in advance was the patenting by Mr. Hiram S. Maxim of various forms of multiple perforated and consolidated powder, powders which would admit the fire into the interior so as to give a longer and more continuous combustion, and also a powder with internal cavities constructed and arranged in such a manner that the tubes or rods might be the entire length of the powder chamber.

The patent was numbered 17,994/94, and the forms of the perforations are illustrated herewith.

It was in connection with the longitudinal perforations that so much was claimed by the author of the article upon which this animadversion is based.

In a letter dated November 21st, 1899, from Sterling Place, Brooklyn, N.Y., addressed to us, Mr. Hudson Maxim makes the following remarks regarding the product named after him and his colleague, Dr. Schupphaus, viz.:—"Maxim-Schupphaus Smokeless Powder" and his claims of invention:

> "My claims were clearly stated in my lecture before the Society of Chemical Industry, London Section, on the 17th of June, 1897 . . . &c. . . . I will, however, outline here briefly some of these claims: 1st. A process and die for the manufacture of longitudinally perforated smokeless powder grains. I do not claim the invention of longitudinally perforated grains in this patent, because such has been made of black powder many years ago."

That the author did make the longitudinal, and later the transverse, perforations the chief point of his invention is borne out by a contribution to the *Scientific American Supplement*, under the date of September 24th, 1898, in which he approvingly quotes an article in *Engineering* of August 20th, 1897, in which the Editor says:

> "*The distingnishing feature* of the gunpowder invented by Mr. Hudson Maxim and Dr. Schupphaus *is its form** . . . Whatever merit there may be in hyperbolic curves in a steam engine, there is none in a gun, for there the object aimed at is to impress the greatest possible amount of energy on the projectile, with the least strain on the weapon. . . . The result is sought to be attained in the Maxim-Schupphaus powder by *giving to each grain such a configuration* that the rate of burning shall keep pace with the motion of the projectile, and still maintain the space behind it with gases at a fairly constant pressure."

* The italics are ours.

The *form*, then, of the powder at that time was considered the chief merit of the invention, in spite of the fact that this form had been patented in this country long ago, as is shown in patent numbered 17,994/94, which describes tubular and other forms of powder which permit internal cavities, &c.

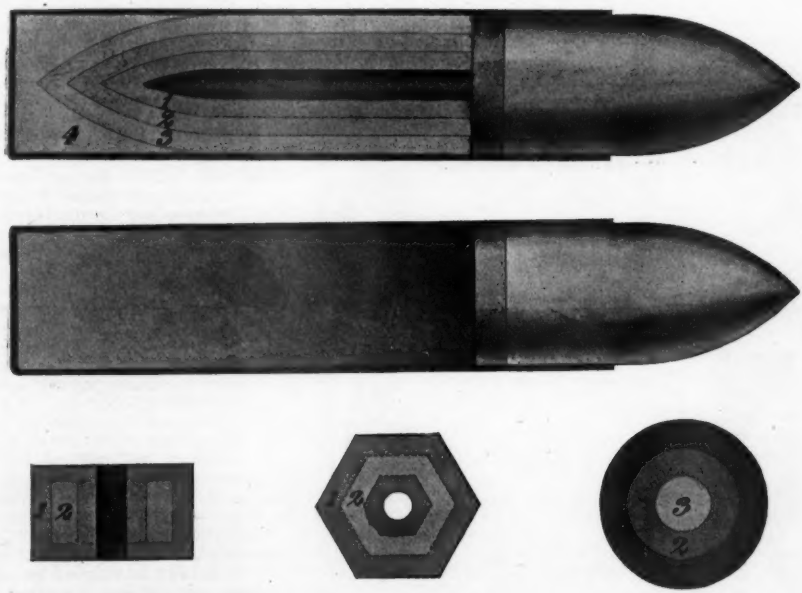
At present, as we see, the author surrenders the claim of the perforations, though he insists on claiming the *die* by which they are produced.

The same letter contains the statement—

> "Another Maxim-Schupphaus claim is the discovery of the peculiar effects of a *small percentage of gelatine gun-cotton with tri-nitro-cellulose*, to render the whole mass plastic and workable under heat and pressure, even when containing a very small quantity of solvent, and also whether or not nitro-glycerine be employed in whatever quantity."

But this idea was patented by Mr. Hiram S. Maxim in England as early as 1888, for in the patent numbered 18,663, on page 1, we read:

> "An important feature of my said invention is the production of an explosive material by the combination with pyroxylin or dissolved gun-cotton, of nitro-glycerine, or nitro-gelatine, or other material which



Mr. Hudson Maxim has also much to say of his claims regarding a powder made of different degrees of slow burning, and so arranged that the slowest is the first to burn, the quick burning the last. He describes the exact formation shown and described in Mr. Hiram S. Maxim's British patent, January 14, 1895. The above cuts are reduced from this patent—No. 1 being the slow burning, and Nos. 2, 3 and 4 being successively quicker.

will redeem the brittleness thereof, and permit of its being moulded while in a dry state, &c."

Which disposes of the claim, therefore, as being quite untenable.

"Another claim is for a transversally perforated rod or grain of powder, the advantages of which above longitudinally perforated powder are clearly set forth in the patent."

Although, as has been seen, the author renounces his claim for *longitudinal* perforations on the ground that such have been made in black powder many years ago, his claim for *transversal* perforation falls equally to the ground, since black powder was also perforated in the direction of its minor instead of its major axis many years ago.

It would be beside the purpose to go into considerations outside those raised in the article in *Cassier's Magazine*, and which the present one is intended either to cancel or supplement, although there are not wanting numerous instances in which the same author has—for what motive we cannot conceive—sought to belittle the just claims of Mr. Hiram Maxim as a prominent investigator in the domain of high explosives. The example of the American publication above mentioned has been emulated by a new London contemporary, *The Spear*, in an article by Mr. Hudson Maxim dealing with the question of aërial torpedoes, which manifests all the idiosyncrasies of the author in his faculty of omission. The statements that have been made by him in the *Scientific American Supplement* of May 10th, 1899, and elsewhere, are equally capable of refutation, and, in fact, are sufficiently answered by the evidence adduced in the present article.

❀ ❀ ❀

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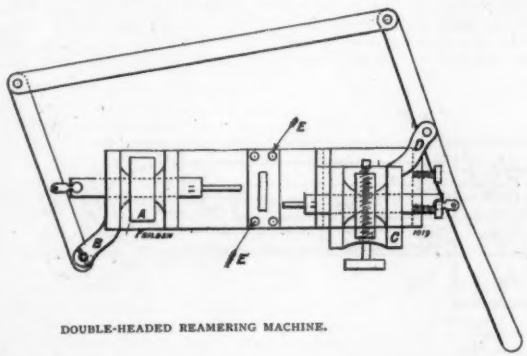
WORKSHOP PRACTICE

The Editor invites skilled mechanics, foremen, under-foremen, and heads of departments, to communicate practical suggestions for publication in the above section, which if accepted will be paid for. Whenever possible, drawings should accompany the contribution.

❀ ❀ ❀

A Parallel Reamering Machine.—The sketch herewith gives a rough idea of a double-head stock reamering machine, which was used with great success in a cycle chain factory for the purpose of reamering the two holes drilled in the chain block. It was necessary that the holes should be an exact distance apart and absolutely in alignment one with the other, or a perfectly regular and straight length of chain could not be produced. The head-stock *A* consisted of an ordinary head-stock attached to the lathe bed, with a driving pulley having a key way attachment to a sliding spindle. At the one end of the spindle a chuck was placed to carry the reamer, and at the other end a ball-cup attachment to a short connecting pin pivoted it to the feeding lever. This feeding lever was jointed on an arm *B* cast on the front of the head-stock and carried past the spindle (where the connection was made) to the rear of the machine. Headstock *C* was similar in construction to head-stock *A*, excepting that, instead of being fixed to the lathe bed, it was placed in a V slide, with a screw feed for adjusting the required distance between the centres of the two head-stocks for the work in hand. When the distance had been obtained, set-pins on the slide locked the head-stock in position. The feeding lever on this head stock was attached to the sliding spindle, and also jointed at the cast arm *D*, but in this instance the lever was carried to the rear of the joint *D* to enable a connecting bar to be attached to the two feeding levers, and also carried to the front of the spindle attachment to provide the arm for the workman to use. When this arm was moved to and fro by the workman, it carried the spindle of the headstock *C* with it, whilst the prolongation of the lever beyond its centre joint at *D* actuated (by means of the connecting bar) the spindle in head-stock *A* in precisely similar fashion. By keeping the distance between the ball spindle connection and the lever joint the same on each head-stock, and the distance from the spindle joint to the connecting bar joint on the *A* head-stock the same length as the head-stock joint to the connecting bar joint on the *C* headstock, the travel obtained in the two spindles would be exactly the same. Any deviation from this rule would cause the one spindle to advance or recede more rapidly than the other. The holder to carry the chain-block to be reamered was placed midway between the two head-stocks, and was attached to the lathe bed by the means of four round pegs *E* sliding into holes in the bed prepared for them. No fixing of the holder was necessary, as the two head-stocks were arranged to travel in opposite directions, thus practically balancing the opposing "pull" of the reamers and making the work of the holder very light.



DOUBLE-HEADED REAMERING MACHINE.

❀❀❀

Making the Most of a Screw-cutting Lathe.—Some time ago I had a job given me to do which involved close personal attention at hard, dirty work. The operation consisted of "chambering" sporting gun-barrels out at the breech end for the cartridge case; the tools provided being a long, coned boring tool, having five fluted teeth the right size and length for the cartridge, the tool running in a 7 in. back-geared screw-cutting lathe. The barrels were in pairs, and it was usual to

place one end of a tube on the tool, bring up the back centre into the other end and feed by hand, the barrels being kept from revolving by inserting into a hole cut in a block of wood, the block being long enough to reach to the lathe bed and rest

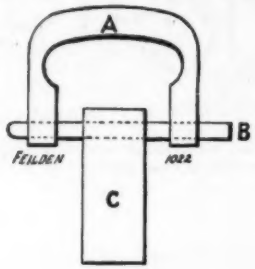


FIG. 1.

thereon. This block was knocked upon the barrels, so that it wedged on them, and was of assistance in drawing the barrels off the tool for the clearance of cuttings. The lubricant fell direct upon the tool. As the cut had to be exceptionally smooth and clean, a frequent clearance was necessary, so that one's two hands were kept fully employed in feeding on and off the tool. This was not at all to my liking, so I set to work to make an alteration, and succeeded in making an automatic feed job of it in the following fashion. The conditions to be filled were—first, preventing the barrels from revolving with the tool by holding fast; second, putting on the cut with the back centre, so that the chambering would be true to the bore; third, obtaining a supply of "suds" for the insertion of a straight round pin *B*. This pin I made to drive tight into the clip and to move freely in the piece *C*, which was simply a piece of round iron turned to fit into the hole in slide-rest used for the tool-holder box. *C* being left loose in this hole, an arrangement was secured whereby the barrel was free to move on the centre of *C* in the horizontal plane and on the centre of *B* in the vertical plane, these movements, together with the adjustable rise and fall of *C* in the slide rest and the horizontal movement obtained by the space allowed between the clip *A* and the piece *C*, made it possible to hold the barrels quite firmly, and yet absolutely free for adjustment to the two centres. The second condition involved an automatic feed for the back head-stock, and this I surmounted in the following fashion. The slide rest was provided with slotted flanges for the usual nut and bolt fastening. Taking advantage of these flanges *D* (sketch 2), I attached two bars of iron, of the size 1 in. × ⅝ in., to them by drilling a hole in the bar near the one end and inserting bolts and nuts, the opposite end of each bar being set round to bring it into position over the back head-stock holding pin *F*. The drilling of another hole in each bar of iron, just large enough for the pin *F* to pass through, made the connection. By screwing the pins down tight at *D*, and the pin *F* down until the head-stock was just free to slide on the lathe bed, the slide rest and back head-stock became practically one, capable of traversing the bed together in unison when actuated by the leading screw-feed.

To fill requirement number three, I made the back centre hollow with a cupped hole on the top, attached a suds can to the back head-stock, so that it too would travel in unison with the rest, and let the suds run through the cupped hole, down the barrel, past the cutting tool, taking the cuttings out with it as it fell into the bosh pro-

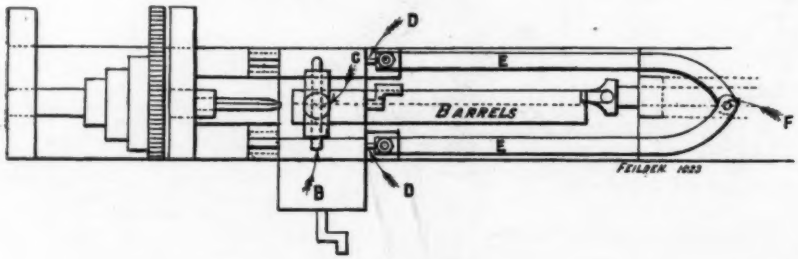


FIG. 2.

running down the barrel from the back centre past the tool to wash the cuttings away, and so save the constant removing for clearance. Sketch No. 1 illustrates the hold-fast holder. The barrels were made fast in the clip *A*, which was simply a piece of 1 in. square iron, bent horse-shoe fashion, and filed out somewhere near the right shape; two ½ in. holes were bored near each end of this clip vided. By varying the change wheels the feed could be arranged to a nicety to suit the work in hand.

The whole arrangement was a perfect success, the work being done well, whilst the flow of suds clearing the tool and keeping it and the barrel cool allowed the operation to be completed without more than one withdrawal of the tool for

clearing, whereas the old system involved probably stopping and clearing a dozen times. The work was completely satisfactory to my employer, the quality being good, and satisfactory to me because I had easier work, and could get through twice the number in a given time. I should think this coupling arrangement could be used to advantage on many other jobs. It did not take me two days' time to make the whole arrangement and set it going. I have left everything in the sketch, save the actual details of the described arrangement, to the imagination, as the conformation of a screw-cutting lathe is well known, and would only make the sketch confusing.

S. MILLS.

Alloys for Brassfounders.—The advent of limited liability and joint stock companies has opened the way for the trade specialist, and changed the old-world rule-of-thumb methods for something more "slick"; and, while it is true that the foundry apprentice of to-day has greater facilities for acquiring technical instruction in the art of making and mixing metals, it is also true that there never was a time when he had less opportunity for the practical exercise of such knowledge.

In most trades there are certain well-defined rules and recipes which have been formulated, and are to be observed in the progress of the business.

Brassfounding—like most other branches of industry—has its trade secrets and formulæ. As a rule, every firm has its own "preserves" in the matter of alloys, and every foreman has his own pet mixtures, which are invariably incomparable, or, at any rate, better than somebody else's.

But, despite the scores of "patent metals" and "finest alloys" on the market, the days of secrets in the metal trades are gone, for nothing can be hid from the chemist who cares to search, or the tradesman who cares to seek intelligently, for the object aimed at in any particular metal.

This article purposes giving the experience of both, by furnishing a list, as well as by making a short examination of the common alloys used in modern brassfoundry practice.

We will proceed by classifying them under three useful sections, viz. : (1) alloys for plumber work, (2) alloys for engine work, (3) special alloys ; and before going further, we would here state that every mixture given is either included in the *pratique* of some reputable firm, or else it is the analyses of castings or material supplied by such firms. Beginning with plumber work, we take cock metal first, as occupying the most important place on the list. Who has not smiled at the oft-recurring phrase in plumbers' accounts—"To—Gun Metal Cocks, $^{T}/_{L}$"? Gun Metal Cocks forsooth!—composed of copper 58%, lead 21%, zinc 19%, arsenic, &c., 2%; warranted to tarnish chocolate-green inside of a week, and to wear out their seats before the arrival of the rainy season.

The modern idea in producing anything for the market is to produce it as cheaply and with as big a margin of profit as possible. Price and appearance are the first considerations; serviceableness and utility come a long way after; and the foreman who can put away the greatest quantity of lead in making so-called "gun-metal" castings is the *rara avis* so frequently advertised for as being "well up in mixtures."

Some years ago a large firm of gas and sanitary engineers that we knew had been carrying on this penny-wise policy in order to compete with the cheap-jack element resolved to end their worries about "leakages and breakages," by reverting back to the system that had made them famous forty years ago. Briefly, that consisted in using only the best materials and mixtures compatible with the requirements of the castings. The result is that they are now in high repute for water, steam and gas fittings.

Part of their method is to remelt all their own borings and filings, keeping each kind by itself. By this means they have always a supply of their own particular alloys in ingots ready to be used in making and improving the new mixtures. It is an axiom in the trade that any alloy is improved by remelting. This accounts for brass, in some form, being included in the making up of shop mixtures. The following table—compiled with a view to efficiency and economy—is a selection from the best mixtures of the more successful firms, and has the merit of being *not* according to the text-books, but good practice, nevertheless.

SECTION I.—*Alloys for Plumbers' Brasswork.*

	Copper.	Tin.	Zinc.	Lead.	Yellow mtl.	Cock mtl.
Cock metal, No. I. ..	53	—	—	7	40	—
" " II.	62	4	—	11	23	—
" " III.	59	4	—	—	21 (I.)	16
Yellow metal	67	—	35	3	—	—
Dipping metal	71	0·5	28·5	—	—	—
"Silveroid" castings	57	—	25	2	Nickel	=16
Electrical "	54	—	30	—	"	=16

SECTION II.—*Alloys for Engineers' Castings.*

	Copper.	Tin.	Zinc.	Lead.	Yellow mtl.	Cock mtl.
"Marine metal"	80	6	8	6	—	—
Bush brass	45	6	—	3	46	—
Bolt metal	14	1	1	—	—	—
Polished fittings	64	4	—	1	8	—
Hydraulic gun-metal.	93	5	2	—	—	10
Special "	86	13	1	—	—	20
Bearings	82	12	—	8	—	—
Worm wheels	86	12	2	—	—	—

SECTION III.—*Special Alloys.*

Aluminium bronze.—Copper 40, Zinc 28, Aluminium 1.
No. II. do.—Copper 55, Zinc 43, Aluminium 2.
Phosphor bronze.—Copper 72, Tin 6, Yellow metal 5, Phosphor Copper 2.
"Ajax" bronze.—Copper 81, Tin 11, Lead 7, Phosphor Copper 1.
Manganese bronze.—Copper 56·78, Tin 0·58, Zinc 41·50, Iron 1·05.
Anti-friction metal.—Copper 1, Tin 3, Antimony 16, Lead 80.
"Plastic" metal.—Copper 3, Tin 48, Antimony 6.

"BRASSEY."

N.B. The foregoing mixtures are all in use at the present time in the best shops on the Clyde, Thames, Tyne, and Forth.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION FROM ALL SOURCES.

CIVIL AND MECHANICAL ENGINEERING.

Lowrie's Power Excavator.—A new steam excavator greatly differing both in design and working from the ordinary "steam navvy," is the invention of Mr. H. C. Lowrie, and although not yet in the market, promises to be very applicable to a wide range of work and conditions. While the ordinary "steam navvy" requires a railway track to be transported to the locality where it is to be used and on which the excavated material can be removed, Mr. Lowrie's machine needs no rails, and thus can be used for many other kinds of work besides railway work, as for instance, in the streets of a city. It carries its own boiler and water tank, and can without difficulty be taken to pieces for shipment, or, possessing its own power, can propel itself along any ordinary road. An illustration of the excavator is given in the *Railroad Gazette*, of December 8th, where it appears as a framed structure of iron on ordinary wagon wheels. A prominent feature is the long boom having a curve at the end to operate on a face greatly below the level on which the excavator rests, and made up of channels, along which a scoop travels on four wheels from the pit up to the level of the conveyor or cart. The curved portion serves to permit the horizontal entrance of the scoop at the beginning of each cut. When the boom is set it remains fixed for excavating, but can be moved into any new position as the operator desires. The scoop is guided by its wheels, and is raised by a chain driven by a winding engine on the main frame and is lowered by its own weight. The discharge is into a hopper built into the plant and thence to either or both sides of the plant at will, or may be led out upon the ground or directed into carts. For railroad cuts, canal beds, and similar cross cuttings, by giving the boom the inclination of the slopes the whole work can be performed at one setting. In grading streets or road it leaves the finished surface always smooth, the ploughing being done as required, while especially in deep cuts too short for the use of the steam navvy, this excavator may be employed with great advantage.

Self-contained Wheel and Motor for Propelling Vehicles.—A novel invention is a device in the shape of a wheel equipped with a motor and entirely self-contained for attaching to vehicles, illustrated and described in a recent issue of the *Scientific American*. The apparatus consists essentially of a heavy wheel, which is journaled in a stout yoke or forks, the head of which turns in a socket, the arrangement resembling the front wheel and forks of a bicycle except that, instead of being controlled by a handle-bar, the wheel is steered by a hand-wheel, shaft, and gear-wheels. To the right-hand fork is attached a two-cylinder gasoline motor, while two gasoline tanks are carried on the other fork. The wheel is driven through a loosely-mounted pinion, which meshes into a gear that is bolted to the spokes of the wheel and a clutch mechanism, the lever for operating the latter being within easy reach of the driver of the wagon. The two cylinders are carried horizontally, one on each side of the fork, with the crank-shaft, upon which is keyed a fly-wheel between them. This motor-wheel is built in various sizes, from 1 h.-p. suitable to a bicycle, up to 4 h.-p. for a carriage, or 10 or more h.-p. for a heavy dray or truck. In attaching the motor-wheel to any vehicle whatsoever, it is merely necessary to remove the framework of the front wheels and bolt the steering socket to the body of the wagon. One material advantage claimed for this device is that no reversing mechanism is necessary, the motor always running in the forward direction. If it is desired to back the vehicle, the motor-wheel is turned completely around in the steering socket and the motor started.

New Types of Radial Drilling Machines.—Although there has been considerable praise for some time in the engineering press of American machine-tools and appliances, this praise has been somewhat marred, as stated elsewhere, by more recent criticism on the part of those who have imported and are using such tools, pointing out that they are too flimsy in construction, and lack that solidity and durability which characterise British-built machinery. Our American cousins, however, are not slow to profit even from the hostile attacks of their opponents, and above all, possess an adaptibility to circumstances that renders them the more formidable competitors in the race for success. As an example of this may be pointed out two machines, illustrated in the *Engineer*, of December 15th, which show that American manufacturers are quite prepared to give to their machinery the more massive proportions that are required by British purchasers.

They are a radial drilling machine and a vertical turret boring machine, both constructed by the Niles Tool Works Co., of Hamilton, U.S., and it is the former to which we desire to attract the reader's attention. Its design is entirely novel, and constitutes its chief merit, though its solidity certainly renders it the more valuable. In the ordinary radial, the overhanging arm—especially in machines of great radius—is liable to vibrate a little when at work; but in the new type this drawback has been entirely removed, for the extreme arm is supported and slides in a movable column, a counterweight being suspended within. The base of this column travels in and is clamped to a circular T-slot in the bed-plate. The arm is raised and lowered by power, and when raised to its full height the end of the drill spindle is 6 ft. 6 in. above the base-plate. The distance from the central fixed column to the spindle in extreme position is 5 ft. 9 in., so that a hole can be drilled within any part of a circle 11 ft. 6 in. in diameter. The whole machine swings around a stationary sleeve, having a bearing high up inside the central column. The heavy base-plate is of quadrant shape, having turned face with T-slots, and work may be clamped to it if desired. The driving power acts upon a vertical shaft in the central column, and is transmitted thence through the cones to the spindle in the ordinary way. The machine promises to be very applicable to heavy work, for most of the jobs would easily come under the bridge, even if in exceptional cases the outer supporting column might be somewhat in the way, and the boring and drilling could be performed with great steadiness and accuracy.

A 2,000 H.-P. Steam Turbine.—The trials of the *Viper* have resulted in showing a considerable increase over contract speed, the boat, indeed, having obtained the record of 41 miles per hour. Thus it would seem that for marine purposes the steam turbine is now established on a thoroughly practical basis. With regard to this subject, Mr. W. Melville, the well-known navy expert, recently made the following interesting observations before the American Society of Mechanical Engineers:—"At the present time it seems as though we had practically reached the highest development possible with existing types of machinery for naval purposes, leaving the designer room only for greater perfection in details. We do not, of course, believe that finality has actually been reached, and it is possible that some radical change may take place which will give us a new type of machinery. Some of the more enthusiastic members of the profession think that the steam turbine is to be the successor of the present steam engine, and assuredly the performance of Parsons' *Turbinia* is sufficiently remarkable to justify the most careful study and further experiment. It is very interesting in this connection to know that in this country the development of the steam turbine is in the hands of one of our famous engineers, who is also one of the honorary members of this society—Mr. George Westinghouse. He has been developing the steam turbine with special reference to its use in driving electrical generators, and some of the results obtained are very remarkable. With his characteristic energy and courage, he is not satisfied with results on a small scale, but is now getting out a steam turbine to develop about 2,000 horse-power on a single shaft, and when this has been built and thoroughly tested we shall be in a position to appreciate more thoroughly the bearing of this form of prime mover on naval engineering."

ELECTRICAL ENGINEERING.

Twin-Carbon Arc Lamps.—Of the recent improvement in electrical lamps, a type of twin-carbon arc lamps recently put on the market by Messrs. Körting and Mathiesen, Germany, is looked upon with considerable favour by some electrical engineers, since it seems to fulfil satisfactorily a desideratum, namely, that of representing an arc lamp having two arcs in series which thereby would possess the advantage that it might be connected singly across a 110-volt circuit. The problem was partially solved some years ago by the construction of an enclosed type of arc lamp, which, taking about the normal pressure, *i.e.*, about 80 volts, could be connected to 110-volt circuit. This lamp, however, was not entirely satisfactory, since the unpleasant hissing of the enclosed light did not permit of the long-burning arc being always used, while, at the same time, the low efficiency of the arc offered another obstacle to its use. The Körting-Mathiesen lamp, which, it is said, has none of these drawbacks, represents a combination of two independent regulating devices attached to a common base-plate; the regulating mechanism is of the type in which a magnet provided with a hinged armature puts the regulating clockwork into motion. Without entering upon the details of its construction, fully described and illustrated in the *Electrical Engineer* of January 19th, it may be stated that the advantage which this lamp offers is that it may be connected—as stated already—singly across a 110-volt circuit, or in pairs across a 220-volt circuit; the latter advantage is especially apparent, since few consumers can employ four to six of the ordinary type of lamp. Like the Nernst lamp, therefore, the new type of lamp facilitates the general endeavour to increase the pressure of current supplied to the consumer; to this is undoubtedly due the drawback that the working cost is considerably higher than with single arcs, for instead of one pair of carbons, the new twin-arc lamp requires two that, though somewhat less in diameter, cost more for the two pairs. To this it must be added that the intensity of light given by the two arcs is not so great as that of one arc consuming an equal amount of energy, and the enclosed type of arc lamp is, as regards intensity of light, considerably superior to the twin-arc type; but even thus, as the inventor maintains, the advantage offered by the twin-arc type is still so great as to render the latter very desirable in connection with central stations supplying 220 volts.

Automotors and Electrical Machinery required in Sweden.—The Consuls of the United States, as has been pointed out on various occasions, are considerably in advance of our own in furnishing useful information to the industrial world, and though intended for the benefit of their own countrymen originally, their reports may be read with advantage by English manufacturers, especially so long as there is such a dearth of information in the British consular reports. We therefore quote from the information sent to his government by the United States Consul at Gothenburg some facts that may interest our mechanical and electrical engineers. It appears that there will be a good opening for the import of motor carriages into Sweden, provided such carriages can be made durable, neat in appearance, safe, and easy to manage. Many cabowners in that country, especially in Stockholm, are contemplating the purchase of automobiles at this moment, and some time ago they sent experts to Berlin to study, examine and report on, motor cabs manufactured in Germany. The report they received, however, was not altogether favourable, and their experts found that automotors which in the price-lists seemed to be perfect, in reality left a good deal to wish for. As regards motor cabs with accumulators or storage batteries, it was discovered that, owing to the batteries being placed close to the back wheels, the steering power of the front wheels was so small that the carriages were unfit for narrow streets, since they could not turn any sharp curves, and were practicable only where there was abundant space to turn. Another drawback was, that as soon as these motors got on a road covered with a layer of sand, even if barely an inch thick, they came invariably to a sudden standstill. Moreover, besides these drawbacks common to motor cabs of German and French manufacture alike, it was stated that few of them were of the type desired, *i.e.* with room for from two to four passengers, and that as a rule they lacked elegancy in appearance—points which intending exporters will do well to bear in mind. A German manufacturer, in conformity with the accommodating spirit and the adaptibility of his nation, declared himself ready, it is reported, to meet the requirements of the Swedish contemplating purchasers, but so far it is not known whether he has received an order. The Swedish cabowners seem to object also to the customary demand of one-fourth of the purchase price for a 30 days' trial, but desire a free trial, being unwilling to expend any money on such expensive machines before having thoroughly satisfied themselves regarding their practical efficiency. This, however, should not deter manufacturers who feel confident of being able to furnish what is required. The field for the time being is, it appears, quite open, for the Consul states that, so far there exists but a single petroleum-motor carriage and one light motor cycle in Gothenburg, and it is said that, with exception of an American motor carriage, there is no other vehicle of the kind in Stockholm.

Another excellent opening, according to the Consul's report, is to arise in the near future for importers of electrical plant. Sweden abounds in waterfalls, and once that its inhabitants realise what benefits they may derive from their wealth of water-power, they will no doubt be eager to import electrical machinery for lighting as well as manufacturing purposes. The beginning is already made, for a large electric-power plant is to be built at Trollhättan; and electric railways and tramways are being planned for Gothenburg, Lund, Bjerröd, and Jönköpping. There is no reason why British manufacturers should not try to be first in the field in this prospective area of electrical engineering, for those who are first are sure to obtain a considerable advantage over their competitors.

MARINE ENGINEERING, &c.

Mechanical Stokers for Marine Purposes.—Mechanical stokers would be a very desirable adjunct to the water-tube boiler on board ship, as it would give uniform stoking and prevent the great waste of heat in a ceaseless opening of the doors of the furnace. In the attempt to reduce expenditure the ss. *Pennsylvania*, built by the Cleveland Shipbuilding Company, and trading on the Great Lakes, has been fitted with mechanical stokers. The dimensions of the *Pennsylvania* are: Length over all, 450 ft.; beam, 50 ft.; depth, 18 ft.; displacement, 10,155 tons. She is fitted with vertical direct-acting inverted jet-condensing quadruple expansion engines, capable of developing 1,600 h.-p. The dimensions of the cylinders are 15¾ h.-p., 23¾ in. first intermediate, 36½ in. second intermediate and 56 in. h.-p., stroke 40 in. The cranks are arranged as follows: h.-p., second intermediate, first intermediate, low-press. Water-tube boilers are used with a boiler pressure of 250 lb. They are of the Babcock and Wilcox type, and the tubes are 2 in. diameter. Three stokers are fitted to each boiler. They consist of a coal hopper, a screw for carrying forward the coal tuyères, and a steam motor for driving the screw. The motor has a reciprocating mechanism, driving a rachet arrangement which turns the screw. The stoker rests on the back and front-bearing bars, and the space between the sides of the stoker and of the furnace is filled up with plates. The exhaust steam from the motor is sent into the ash-pit. Along the upper sides of the stoker, inside the grate, are a number of holes through which air is blown on the glowing coal. As the coal is pushed forward by the screw it rises, and when it comes to the grate level it fires, and is coked; the gases rising from the coal, mixes with the air and gets properly consumed. The clinker formed is taken away by side doors by the stoker. These side doors may be used for supplying coal to the grate in case of accident to the stoker. The coal used in the test was fairly dirty, which had a colorific value of 11,790 The tests showed that an average of 23·1 lb. of steam was used to operate the stokers; for the six this was 138·6 lb. The cost for stokers and blower was 4·29 per cent. of the steam generated; but as

the blower exhaust goes through the feed-water heater, the cost of the stoker installation is 1·68 per cent. of the steam made. On May 30 and 31, the average boiler pressure was 240·8 lb. steam pressure; at cylinder, 237·2 lb.; vacuum, 22·73; cut-off in h.-p. cylinder, ·542; mean effective pressure, 26·24 lb.; revolutions, 79·24; i.-h.-p., 1,455; temp. of feed, 219 lb. of water per i.-h.-p., 14·40; main engines auxiliaries, 2·33 lb.; coal per i.-h.-p., main engines, 1·72 lb.; water evaporated per lb. of coal, from and at 212°, 8·85 lb.; per lb. of combustible, 11·32 lb.

Belleville *v.* Scotch Boilers.—Mr. Howden on one occasion challenged Messrs. Maudsley & Field to a trial between the two types of boilers—the Belleville and the Scotch type with forced draught. It will be interesting to those who read the challenge and who have, not for long, made up their minds on the water-tube boiler question, to learn that such a trial is now going on with the boilers fitted in H.M. s.s. *Minerva* and *Highflier*. They are cruisers of about 5,000 tons, and the *Highflier* is fitted with eighteen Belleville boilers, while the *Minerva* is fitted with eight Scotch boilers. The horse-power developed by the *Highflier's* engines when the boilers are making steam with natural draught is 10,000, while the engines of the *Minerva*, when the boilers are under forced draught, develop about 9,600 horse-power. The trials are to be thirteen in number, varying in periods from twelve to sixty hours. The trials will be considerably exhaustive. After steaming from eighteen to thirty-six hours at a low speed, the two will at a signal spread fires or light them and put on full steam. The trials are off Gibraltar. The ships are working in company and subject to the same external influences, with coal of same kind. Some trials have shown that the stoking with the water-tube boilers was not of an expert kind. The stokers will require considerable further practice, for it is said 25 per cent. more coal was required in the case of the water-tube boilers than in the other case. The trials are not yet complete.

The Drop in Multiple Expansion Engines.—Professor Weighton has been making experiments on the question of the drop in multiple-expansion engines. These experiments were made with a two-cylinder, three-cylinder, and four-cylinder experimental engine at the College of Science, in Newcastle-on-Tyne. The question he set himself was to determine the most economical point of cut-off in the larger cylinders of multiple expansion engines—that is, in the low-pressure cylinder of a compound engine, in the intermediate and low-pressure cylinder of a triple expansion engine, and in the two intermediate and low-pressure cylinders of quadruple expansion engines. He also wished to determine the precise drop between any two cylinders and the effect produced by different drops. The cylinders of his engine had the following diameters: 7 in., 15½ in., 23 in. by 18 in. stroke. With some experiments he used steam in the jackets, in others not. The steam-chest pressure was 201 lb. per square inch. He found that with any two cylinders to obtain best economy it was necessary to cut off steam at a certain point in the larger cylinder, and this point depends on the ratio between the capacities of that cylinder and the preceding cylinder. The relation may be expressed in the form of a fraction:—

$$\frac{\text{Maximum-economy cut-off}}{\text{Stroke}} = \frac{R + 6{\cdot}6.}{6{\cdot}6\ R.}$$

He also found that their point of cut-off should be constant throughout, however the cut-off in the higher pressure cylinders may vary. In low pressure cylinders of triple expansion engines and the second intermediate and low pressure cylinders of quadruple expansion engines, the point of cut-off of maximum power coincides with the point of cut-off of maximum economy. But maximum power point of cut-off in the second cylinder of triples and quadruples is much later than that of the maximum economy point of cut-off. In compounds it is only slightly later. Jacket steam does not influence in the least the maximum economy point of cut-off. Variation of vacuum capacity also has no influence on the same factor. The revolutions of the engine were about 140, the brake h.-p. 141, and the i.-h.-p. 152, the consumption of steam being between 14·4 lbs. and 15·98 lbs. per brake h.-p. per hour. It will not be correct, however, to assume that the jacket steam would make no difference in all engines. Sir John Durston in some of his latest trials showed that there was little difference in economy with the use of jacket steam with high-speed engines, but when the speed was comparatively slow the effect was different—there was a marked economy. Were some one else to make trials with another set of engines working under different conditions, the effect might be quite different from that found in the trials of the Durham College engine. The experiments do not deal with the best cylinder ratios, nor with the manner in which cylinder ratios affect the best point of cut-off.

MISCELLANEOUS.

Bobbin Lever for Gassing Frame.—The gassing of yarn, whether of cotton or silk, requires sharp, intelligent, and trustworthy work-people, especially for the piecing up a broken end and restarting the bobbin in conjunction with operating the device for controlling the gas jet. On these occasions care must be taken by those in charge that the flame does not come in contact with the yarn before the bobbin has obtained its proper speed; and, of course, the yarn, on the other hand, must not be allowed to run on without encountering the gas flame. Lazy work-people are naturally tempted to permit the yarn to keep running without getting near the flame, and, without special precautions, might do so undetected. To prevent either of these occurrences, various devices have been invented by machine makers, permitting the worker to adjust the parts at the proper time of starting, but none of them is entirely successful. The latest improvement in such devices is

the invention of Mr. James Heathcote, of Macclesfield, which has been adopted by Messrs. Tomlinson, Ltd., of Rochdale, and said by them to give better satisfaction than any other arrangement. It is designed to control the gas automatically, and is based upon the action of levers that stop and start the motion of the bobbin. By the aid of this invention the trigger, formerly used, and actuated by the workman in charge, is no longer necessary, the various parts being entirely controlled from the front. It is, moreover, so devised that the operator cannot let the yarn pass without coming in contact with the flame, and he has no alternative but to bring the latter into service as soon as the bobbin has attained its proper speed.

Another American Invasion.—It is reported that the British Thomson-Houston Company representing the General Electric Company of Schenectady—the largest manufacturers of electric machinery in the world—are about to follow the example of the Westinghouse Company and establish works in this country. It is proposed to establish these on a large scale at Rugby.

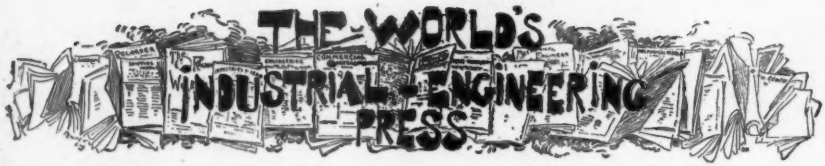
Tenders and the "Board of Trade Journal."—A most striking example of belated information occurs in the *Board of Trade Journal*, published on January 18, where it is stated that the Secretary of State for India is prepared to receive tenders from such persons as may be willing to supply (1) covered goods wagons, (2) oil-tank wagons, and that the conditions may be obtained on application to the Director-General of Stores, India Office, Whitehall, S.W., &c.; but that tenders are to be delivered at that office by two o'clock p.m. on Tuesday, January 23, 1900, which gives intending competitors just five days' time, which, it will be granted, is rather short notice; but this is nothing in comparison to what follows. In the *Board of Trade Journal* of the same date, *i.e.*, January 18, the useful information is proffered that the Secretary of State for India in Council is prepared to receive tenders from such persons as may be willing to supply (1) locomotives, (2) brass boiler tubes, and that tenders for the latter are to be delivered on Tuesday, January 16 (*sic!*), 1900, after which time no tender will be received, *i.e.*, that the ultimate term had elapsed two days before the publication in the *Board of Trade Journal* appeared.

A Busy Year.—Messrs. Geipel and Lange advise us that the past year has been a very busy one with them, they having executed a large quantity of electrical power transmission plant for well-known firms in this country; their steam trap, also, whose reputation is now permanently established, is still increasing its already extensive vogue. It has been fitted into the new Royal Yacht, and a large number of H.M. war vessels.

About the Use of Liquefied Air in Industrial Practice.—Relating to Dr. Hampson's results mentioned on page 253, Vol. I., it may be interesting to see what Professor Linde, the German expert, mentioned recently. The most important questions in this respect are, "how expensive liquid air can be made, and how long it can be kept." As to the first question, it can be stated that 1 kilogram of air requires 3 h.-p., or, if larger machines are used, 2 h.-p. (1 lb. about 1 h.-p.). The present machines are not quite perfect, but there is an outlook that 1 kilogram shall be made with power consumption of $1\frac{1}{2}$ h.-p. (1 lb. about $\frac{3}{4}$ h.-p.). As to the second question, Professor Linde states that the liquid air can be kept in a Dewar bottle for about a fortnight before it is completely evaporated. Referring to the different applications for liquid air, he remarks that it is an imminent agent for producing low temperatures, as its usual temperature is 190° C. As such it should prove useful for the graduating of thermometers. It has already been successfully used in medicine for cooling. As an article of luxury it is further mentioned instead of ice on the dinner-table for cooling hot dishes or beverages. A special advantage should be that liquid air evaporates to the last drop! More important is the use of liquid air for the making of a mixture extraordinarily rich in oxygen. The vapours formed by evaporation of the liquid contain 92 per cent. nitrogen and 8 per cent. oxygen, so that a mixture rich in oxygen is left behind. This can be used, for instance, for the complete combustion of low-grade coal, or in metallurgy. Mixed with powdered coal or petroleum, it becomes a valuable explosive, which has already been successfully tested in blasting rocks. It is, of course, a great drawback that the cartridges once made have to be used immediately. Perhaps this difficulty could be overcome when used in systematic working order.

"Britannia."—March Number. The third article of Mr. Herman Marcus's series on the "Forms of Government existing in the British Empire" deals with India. The ability shown in previous articles will be a guarantee for its excellence. The engraved portrait for the *Gallery* is of Sir Christopher Wren, a very fine one, and an appreciation of the man and his work is to accompany it. A very striking article on "Boer Inhumanity" comes from Dr. Oswald Marling, of Toronto. The cartoon, as usual, is from Mr. John Proctor, and many additional illustrations are to be given. The carefully selected abstracts of opinions from the best newspapers of the Empire are continued, and the *Diary of Progress* and the *Guide to Books*, &c., on national subjects. Mr. J. W. Root, author of *Tariffs and Trades*, writes on "Famines in India." In interest and quality, as well as in bulk and scope, "Britannia" is on the upward move.

Balanced Expansion Joint.—We shall publish in our next issue some interesting particulars, forwarded by Messrs. Brown & Co., of 49, Deansgate, Manchester, concerning a new balanced expansion joint and a floating metallic packing presenting some unique features.



List of Publications Reviewed and Index to Abbreviations.

American Machinist	New York	*Am. Mach.*
American Manufacturer & Iron World	Pittsburg	*Am. Mfgr. and Ir. Wld.*
American Shipbuilder	New York	*Am. Shipbldr.*
Annales des Ponts et Chaussées	Paris	*Ann. des Pts. and Chauss.*
Architect	London	*Archt.*
Architectural Record	New York	*Arch. Rcd.*
Architectural Review	Boston U.S.A.	*Arch. Rev.*
Australian Mining Standard	Sydney	*Aust. Min. Stand.*
Automotor & Horseless Vehicle Journal	London	*Autom. and Horsel. Veh. Journ.*
Berg und Hüttenmannische Zeitung	Berlin	*Berg Hüttenm. Ztg.*
British Architect ...	London	*Brit. Archt.*
Builder	London	*Bldr.*
Bulletin de la Société d'Encouragement	Paris	*Bull. d. l. Soc. d'Encour.*
Canadian Architect ...	Toronto	*Canad. Archt.*
Canadian Electrical News	Toronto	*Canad. Elec. News.*
Canadian Engineer ...	Montreal	*Canad. Engr.*
Canad. Mining Review	Ottawa	*Canad. Min. Rev.*
Colliery Guardian ...	London	*Coll. Guard.*
Comptes Rendus de l'Acad. des Sciences	Paris	*Compt. Rend.*
Dingler's Polytechnisches Journal	Stuttgart	*Dingler's Polyt. Journ.*
Eclairage Electrique..	Paris	*Ecl. Elect.*
Electrical Engineer ...	London	*Elec. Engr.*
Electrical Engineering	Chicago	*Elec. Engrg.*
Electrical Review ...	London	*Elec. Rev.*, London
Electrical Review ...	New York	*Elec. Rev.*, New York
Electrical World ...	New York	*Elec. Wld.*
Electrician	London	*Electn.*
Electricien	Paris	*Electn.*, Paris
Electricity	London	*Electy.*, London
Electricity	New York	*Electy.*, New York
Elektrochemische Zeitschrift	Berlin	*Elektrochem. Ztschrft.*
Electrotechniker ...	Vienna	*Electrotechniker*
Elektrotechnische Zeitschrift	Berlin	*Elektrotech.Ztschrft.*
Elettricita	Milan	*Elettricita*
Engineer	London	*Engr.*
Engineer	Cleveland U.S.A.	*Engr.*, Cleveland
Engineering	London	*Engrg.*
Engineering & Mining Journal	New York	*Engrg. and Min. Jour.*
Engineering Magazine	New York & London	*Engrg. Mag.*
Engineering News ...	New York	*Engrg. News*
Engineering Record ...	New York	*Engrg. Rcd.*
Gas Engineers' Magazine	Birmingham	*Gas Engrs'. Mag.*
Gas World	London	*Gas Wld.*
Génie Civil	Paris	*Gén. Civ.*
Gesundheits-Ingenieur	Munchen	*Ges. Ing.*
Glaser's Ann. f. Gewerbe und Bauwesen	Berlin	*Glaser's Ann.*
Heating & Ventilating	New York	*Heatng. and Ventng.*
Indian & Eastern Engineer	Calcutta	*Ind. and East Engr.*
Indian Engineering ...	Calcutta	*Ind. Engrg.*
Industries & Iron ...	London	*Ind. and Ir.*
Iron Age	New York	*Ir. Age.*
Iron and Coal Trades Review	London	*Ir. and Coal Trds. Review*
Iron & Steel Trades Journal	London	*Ir. and Steel Trds. Journ.*
Journal of Electricity	San Francisco	*Journ. of Elec.*
Journal of Gas Lighting	London	*Journ.of Gas Lghtng.*
Journal of Royal Inst. of British Architects	London	*Journ. of Roy. Inst. of Br. Archts.*
Journal of the Society of Arts	London	*Journ. of Soc. of Arts*
Locomotive Engineering	New York	*Locom. Engrg.*
Machinery	London	*Machinery*, London
Machinery	New York	*Machinery*, N. York
Marine Engineer ...	London	*Mar. Engr.*
Marine Engineering ...	New York	*Mar. Engrg.*
Mechanical World ...	London	*Mech. Wrld.*
Mechanical Engineer	Manchester	*Mech. Engr.*
Mining Journal ...	London	*Min. Journ.*
Mitt. aus d. Kgl. Tech. Versuchsanst	Berlin	*Mitt. a. d. Kgl. Teck. Versuchsanst*, Berlin
Nature	London	*Nature*
Nature	Paris	*Nature*, Paris
Oest. Monatsschr. f. d. Oeff. Baudienst	Vienna	*Oest. Monatsschr. f. d. Oeff. Baudienst*
Oest. Zeitschr. f. Berg und Hüttenwesen	Vienna	*Oest. Zeitschr. f. Berg u. Hüttenwesen*
Power	New York	*Power*
Practical Engineer ...	London	*Pract. Engr.*
Railway Master Mechanic	Chicago	*Railw. Mast. Mech.*
Railway World	London	*Railw. Wrld.*
Scientific American ...	New York	*Sci. Am.*
Scientific American Supplement	New York	*Sci. Am. Suppl.*
Stahl und Eisen ...	Dusseldorf	*Stahl u. Eisen*
Stone	New York	*Stone*
Western Electrician ...	Chicago	*West. Electn.*
Zeitschr. d. Oest. Ing. u. Arch. Ver.	Vienna	*Ztschrft. d. Oest. Ing. u. Arch. Ver.*
Zeitschr. d. Ver. Deutscher Ingen.	Berlin	*Ztschrft. d. Ver. Deutsch. Ing.*
Zeitschrift für Elektrochemie	Halle a. S.	*Ztschrft. f. Elektrochem.*
Zeitschrift für Elektrotechnik	Halle a. S.	*Ztschrft. Elektrotech.*

ARCHITECTURE AND BUILDING.

1. Construction and Design.

Domes.—*The Dome as the Basis of an Architectural System.* By Arthur Bolton. The author points out that a tendency exists to regard the dome as an isolated feature, centralising in character, rather than as the expression of a principle, capable, as the vault proved to be in the hands of Gothic architects, of pervading the whole structure of the building to which it is applied. Such a proposition may perhaps be deduced from the application of the dome in buildings of more than one epoch. The author, however, maintains that the dome must be regarded as the basis of an architectural system, and supports his view by analysing two types of domed buildings to be met with in the Renaissance of Italy. (To be continued.) 3 cols.—*British Architect*, Jan. 19th, 1900.

—— *The Dome as the Basis of an Architectural System.* By Arthur Bolton. Complete text of the author's paper read before the Architectural Association on Jan. 12th, with abstract of the discussion following. 14½ cols.—*Builder*, Jan. 20th, 1900.

2. Heating Ventilation and Sanitation.

Ventilation.—*Ventilation and Heating of the Rookwood Pottery, Cincinnati* Description of an interesting ventilation and heating arrangement in the new works added to the older plant of the pottery. 1½ col.—*Engng. Rcd.*, Jan. 13th, 1900.

—— *Ventilation and Heating of a Baltimore Schoolhouse.* Description of an indirect heating system possessing a number of striking features recently installed in a new school building at Baltimore, Md., U.S.A. (Ill.). 4½ cols.—*Engng. Recd.*, Jan. 6th, 1900.

3. Plumbing and Gasfitting.

4. Miscellaneous.

CIVIL ENGINEERING.

1. Bridges.

Bridges.—*The Design of Beams. XXXIII.* By W. H. Atherton (continuation). Description of the Linville girder, being a type of parallel braced girder which has been largely adopted in bridge work. (Ill.). 1½ col.—*Mech. Wrld.*, Jan. 26th, 1900.

—— *Continuation of the Debate on the Report of the Committee on Material for Iron Bridges.* Full report of the speeches. 20 cols.—*Ztschrft. d. Oest. Ing. u. Archit. Ver.*, Jan. 19th, 1900.

—— *The Davenport and Rock Island Bridge over the Mississippi.* Description, accompanied by a two-page plate, of this interesting engineering work. (Ill.). 7 cols.—*Engng. News.*, Jan. 11th, 1900.

2. Canals, Rivers and Harbours.

Canals.—*The Waterways of Russia.* By C. H. Moberly, M. Inst. C.E. (Continued.) The present instalment deals with the Waterways of Finland, and the Rivers of the Caucasus and the Caspian Sea. 4½ cols.—*Engng.*, Jan. 19th, 1900.

3. Irrigation.

4. Miscellaneous.

ELECTRICAL ENGINEERING.

1. Electro-Chemistry.

Electro-Chemistry.—*Recent Electro-Chemical Progress.* By C. Knox Harding. Summary of progress in electro-chemical industry. 1½ col.—*West. Electrician*, Jan. 6th, 1900.

—— *Progress of Electro-Chemistry in* 1899. (Conclusion.) Review of the progress of the electro-chemical industries during last year. 4½ cols.—*Electrotechniker*, Jan. 15th, 1900.

Electrolysis.—*A new Electrolytic Process of Manufacturing Chemicals.* Description of a new process of separating chlorine and sodium by the direct decomposition of salt by electrolysis, without the introduction of any other ingredient. This process is called the Hargreaves-Bird process which is claimed to be much more economical and simple than those formerly employed; one difference between it and the Kastner-Keller process in use in the Liverpool district for some time, being that mercury is used in the latter, but not in the former. 1½ col.—*Elec. Rev.* (New York), Jan. 10th, 1900.

—— *Apparatus for Use in Experimental Fusea Electrolysis.* By Alec. A. Beadle. The author offers some hints to overcome the difficulties encountered in the electrolysis of fused salts. (Ill.). 1½ col. (To be continued.)—*Elec. Rev.* (London), Jan. 19th, 1900.

—— *Production of Soda, Hypochlorites, Chlorine, and Chlorates.* Description of many of the newest electrolytical methods and their results. (To be continued.) 4 cols.—*Electro-Chem. Rev.*, Jan., 1900.

Electro-Metallury.—*Aluminium.* Article dealing with the wonderful development of the production of aluminium, surpassing the wildest dreams of 25 years ago, and discussing the future prospects of the electrolytic methods. 2 cols.—*Electro-Chem. Rev.*, Jan., 1900.

—— *The Electro-Chemical and Electro-Metallurgical Industries in* 1899. By John B. C. Kershaw. Conclusion of a very interesting summary of the progress made in these branches of industry. 3½ cols.—*Elec. Rev.* (London), Jan. 19th, 1900.

2. Electric Lighting.

Accumulators.—*The Chloride Batteries.* Account of the chloride batteries and description of the plant of the Chloride Electrical Storage Syndicate at Clifton Junction, near Manchester, which covers three acres and is admirably situated for the purpose. (To be continued.) 2 cols.—*Electro-Chem. Rev.*, Jan., 1900.

Central Stations.—*Progress of Central Station Work.* By Homer E. Niesz. Account of improvements in central station work tending toward more economical generation, transmission and distribution of current for all purposes. 2½ cols.—*West. Electrician*, Jan. 6th, 1900.

—— *Electricity Supply from Central Stations.* Abstract of a paper by Mr. J. W. Lieb, Junr., manager of the Edison Electric Illuminating Co., New York, read before a meeting of the N. Y. Electrical Society, on Dec. 21st, 1899. (Ill.). ¾ col.—*West. Electrician*, Jan. 6th, 1900.

Electric Lamps.—*Twin-Carbon Arc Lamps.* Account of a lamp recently introduced by Messrs. Körting and Mathieson, Germany. The advantage of these lamps is claimed to be that they may be connected singly across a 110-volt circuit. A few years back there appeared on the market an enclosed type of arc lamp, which to some extent met this requirement. As regards intensity of light, they are, compared with the twin arc type, still considerably its superior; but, says Mr. Mathieson, though the cost of his lamps is higher than that of single arc, the advantages of the latter are still superior. (Ill.). 1 col. *Elec. Engr.*, Jan. 19th, 1900.

—— *Relative Candle-Powers of Alternating and Direct Current Enclosed Lamps.* Abstract of a paper read by Mr. E. P. Warner before the December meeting of the Chicago Electrical Association. 1½ cols. *Elec. Wrld. and Engr.*, Jan. 13th, 1900.

Electric Light.—*Installing and Operating an Electric Lighting Plant.* By W. H. Wakeman. The article deals with selecting types, wiring,

methods of putting up wires, cut-outs, feeders, switches, &c., and general suggestions. 7½ cols. *Engr.* (*Cleveland*), Jan. 1st, 1900.

Electric Light.—*Electric Plant and Street Lamps of Trieste, Austria.* By Joseph Herzog. The engine house at the central station has been designed for five sets of machines, of which three sets have been installed. The three-phase generators, which have a stationary armature and rotating field magnets, are direct-coupled to suitable steam-engines, and at 105 revolutions per minute generate a voltage of 2,000. The exciter armature is mounted directly on the shaft of the generator. (Ill.) ½ col. *Elec. Wrld. and Engr.*, Jan. 6th, 1900.

—— *Electric Lighting in Pretoria.* (Ill.) 1½ col. *West Electrician*, Dec. 30th, 1899.

Incandescent Lamps.—*The Defects of the Incandescent Electric Light.* The author points out that incandescent light from a hygienic point of view is excellent, except that the uncovered lamps greatly injure the eyesight. Ground-glass bulbs cause dizziness and headache. He recommends as a remedy the so-called "spiral globe," which is a spirally-coiled rod of glass, forming an envelop of the bulb. 1½ col.—*Pub. Health Engr.*, Jan. 20th, 1900.

Protection of Transmission Wires.—*On the Protection of Electric Power Transmissions from Lightning.* By J. T. Morris. (Continued.) Description of various lightning arresters. (Ill.) 1 col. *Elec. Rev.* (London), Jan. 19th, 1900.

3. Power.

Alternating-Current Circuits.—*Compensation of Line Drop in Alternating Currents.* By E. J. Borg. The author gives an illustration of the practical application of the general equation giving relation between currents and e. m. f. in an alternating-current system. 5½ cols.—*Elec. Wrld. and Engr.*, Jan. 13th, 1900.

Alternators.—*A New Method for Compounding Alternators.* Description of a compensated revolving field alternator manufactured by the General Electric Co., of Schenectady, N.Y. (Ill.) 2½ cols.—*Engng. News*, Jan., 4th, 1900.

Calorimeters.—*Steam Calorimeters.* The article describes the separating calorimeter and the throttling or wire-drawing calorimeter, and adds a log form for use with the latter. (Ill.) 7½ cols. *Mech. Engr.*, Jan. 20th, 1900.

Converters.—*The Rotary Phase Converter.* By Prof. R. W. Quick. Interesting article on the subject of converters in which the author reaches by the analysis the generali-ation that in all cases of m to n phase transformation, a tapping point on one side of the armature for m phases should coincide with a tapping point of the opposite side of the armature, for n phases. 6 cols.—*Elec. Wrld. and Engr.*, Jan. 6th, 1900.

Electric Circuits.—*Underground Distribution of Two-Phase Current in New York City.* The article deals with the subject of testing faults and describes a device designed by Superintendent Sparrow, of the Manhattan Co. 3½ cols. *Electricity* (London).

Electric Cranes.—*Electric Travelling Cranes.* Description of cranes on the most advanced plan, constructed by Messrs. Joseph Adamson & Co., of Hyde, Cheshire, built for Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., of Openshaw. (Ill.) 2¾ cols.—*Engng.*, Jan. 5th, 1900.

Electrical Distribution.—*Three-Wire Distribution from one Machine.*—By Edward Bretch. Description of a system for that purpose. 1½ col. *Elec. Wrld. and Engr.*, Jan. 13th, 1900.

Electrical Machinery.—*Electrical Machinery in the Harrison Street Station of the Chicago Edison Company.* Description of machinery closely analogous to rotary converters and supplying currents simultaneously to the busbars of the low-tension direct-current distribution system, and the three-phase current at 25 cycles per second to a group of stationary transformers for stopping up to a high voltage for transmission. (Ill.) 1 col.—*Elec. Rev.*, New York, Jan. 3rd, 1900.

Electrical Machinery.—*Electrical Installation on Battleships.* Description in detail of the Electric Plants of the Battleships Kearsage and Kentucky. By Naval Constructor J. J. Woodward, U.S.N. (to be continued). (Ill.) 3 cols.—*Engng.*, Jan. 5th, 1900.

Electric Motors.—*Three-phase, 3,500 Kilowatt Unit for the Metropolitan Station in New York.* Description of some of the largest steam-driven dynamos in the world. (Ill.) ½ col.—*West. Electrician*, Dec. 30th, 1899.

—— *The Lundell Motor.* Account of a motor of the two-pole type, of which the distinctive feature lies in the construction of the field magnets, and only a singer energising coil is required to magnetize all the pole pieces. (Ill.) ¾ col.—*Industries and Iron*, Jan. 19th, 1900.

Electric Plant.—*Leicester Corporation Electricity Works.* Description of a fine plant, furnished with Ganz alternators and two 1,000 K.W. Brush inductor alternators. (Ill.) 2¾ cols.—*Elec. Rev.* (London), Jan. 26th, 1900.

—— *Lighting and Power Installation of the New Post Office Department Building, Washington, D.C.* By J. P. Alexander. There are four units in the electrical installation, which consists of four 120 K.W. Tresher direct-coupled dynamos running at 240 revolutions, and delivering currents at 115 volts. These machines have been observed to stand a drop of 650 amperes without sparking. The units are arranged in two sets, with cylinders end to end, right and left-handed units being paired. (Ill.) 2 cols.—*Elec. World & Engr.*, Jan. 6th, 1900.

—— *The Kalamazoo Valley Electric Company's Plant.* By Wm. G. Fargo. Description of a recently completed water-power plant netting an average of 200 horse-power at the water-wheel shaft. This power is transmitted at 25,000 volts to Kalamazoo city, a distance of 22 miles, and thence to Battle Creek, a total distance of 76 miles. It is the intention to extend the line to Jackson, which will make a total of 90 miles of transmissions. (Ill.) 4 cols.—*Engng. Recd.*, Jan. 13th, 1900.

—— *The Albion, New York, Power Transmission Plant.* Description of a small typical power transmission and distribution plant in Albion, Orleans County, New York, of which the generating station is located at Waterport. (Ill.) 2 cols.—*Elec. Rev.*, New York, Jan. 3rd, 1900.

—— *Bolton Corporation Electricity Plants.* Description of a new generating plant put down for the double purpose of supplying power to the tramways and to the direct current lighting mains at Bolton. (Ill.) 5 cols.—*Elec. Rev.*, London, Jan. 19th, 1900.

—— *Light, Heat, and Power Supply in the Cable Building.* Full description of the plant of the cable building in Chicago, U.S.A., built for the Cable Piano Co. (Ill.) 2½ cols.—*West. Electrician*, Dec. 30th, 1899.

—— *The St. Lawrence Power Plant.* Description of a very large power plant located near Massena, St. Lawrence Co., New York. The water power is derived from the Grass River, a tributary of the St. Lawrence, and will be distributed electrically for manufacturing and allied purposes. The first supply will be about 70,000 horse-power, with provision for the future development of 110,000 horse-power more. The property of the St. Lawrence Power Company, comprising 2,000 acres of land, will be accessible by branches of the New York Central Road, and by a channel to the St. Lawrence large enough to accompany vessels of as deep draft as required. (Ill.) 7 cols.—*Engng. Recd.*, Jan. 6th, 1900.

—— *A Typical Converter, Motor Generator, and Storage Battery Sub-station Plant.* Description

of the interesting sub-station plant, embracing the switchboard and charging sets of the Edison system used in the down-town district of the Buffalo General Electric Company. (Ill.) 1½ col. —*Elec. Rev.* (New York), Jan. 3rd, 1900.

Electric Plant.—*The New Power Station of the Third Avenue Railroad Company.* The article deals very fully with the details of this gigantic installation, described in many engineering journals. (Ill.) 7⅞ cols.—*Engng. Recd.*, Jan. 6th, 1900.

—— *Cambridge Electricity Supply Works.* Description of the plant constructed by the Cambridge Electric Supply Company. (Ill.) 7 cols.—*Contract Journ.*, Jan. 17th, 1900.

Electric Power.—*Electric Power in a Tobacco Factory.* Description of the plant in the Liggett and Myers Tobacco Factory at St. Louis, Mo., U.S.A. The plant produces no less than 1,000 h.-p. by motors, ranging from 4 to 70 h.-p. (Ill.) 1 col. —*West. Electrician*, Dec. 30th, 1899.

Electric Power Transmission.—*Alternate Current Power Transmission.* By O. Du Riche Preller, M.A., Ph.D. Description of the distribution of energy and the practical working results obtained at three typical installations, viz., that of the Sihl Works (Canton Zurich), the Rathausen Works (Canton Lucerne), and the Ocken-Aarburg Works (Canton Aargau), in Switzerland, all of which utilise their full available hydraulic power, and therefore constitute interesting examples of self-contained central stations, transmitting and distributing energy over large areas. (Ill.) 4½ cols. —*Engng.*, Jan. 12th, 1900.

Electrical Transmission.—*Polyphase Transmission.* Abstract of a paper by Chas. F. Scott, read before the National Electric Light Association, March 1st, 1894, and revised by the author in 1899. 15 cols.—*Journ. of Elec., Power and Gas*, Dec. 1899.

—— *The Electrical Transmission of Power.* Abstract of a paper read by Mr. G. H. Bowden, of Messrs. D. Selby Bigge and Co., at a meeting of the Glasgow University Engng. Soc., Jan. 11th, 1900. 1¾ col.—*Electr. Engr.*, Jan. 19th, 1900.

Generators. — *Compounding of Alternating-Current Generators.* Description of a new method of compounding, employed by the General Electric Company, U.S.A., which consists in passing the current of the generator to be regulated through the armature of the exciter, thereby producing in the exciter armature alternating polarities which reverse in synchronism with the movements of the armature in space across its field poles. The article summarizes the specification of the patent of Mr. E. W. Rice, jun. on this method of compounding. 1⅜ col.—*Elec. Wrld. and Engr.*, Jan 6th, 1900.

Hauling Gear.—*Some New Electric Machinery.* Description of a particular form of crane motor, an electric type motor, a compact plant for torpedo-boat destroyers of the Russian Navy, &c., constructed by Ernest Scott and Mountain.—*Engr.*, Jan. 12th, 1900.

Motors.—*Alternating-Current Power Motors.* Abstract of a paper by W. A. Layman read before the Engineers' Club, St. Louis, Mo., U.S.A. The article describes the system of direct and alternating currents in great detail and refers to their respective advantages.—*Mech. Engr.*, Jan. 20th, 1900.

—— *Alternating-Current Power Motors.* Abstract of a paper by W. A. Layman read before the Engineers' Club, of St. Louis, Mo., U.S.A. (continued). The present instalment deals with the induction motor. (Ill.) 4¼ col. — *Mech. Engr.*, Jan. 27th, 1900.

Rotary Converter.—*The Largest Rotary Converter.* Description of one of several rotary converters built for the Third Avenue Railroad Company, New York, which are the largest ever constructed, being of 1,000 kilowatts capacity each. (Ill.) 1½ col.—*Elec. Rev.* (New York), Jan. 3rd, 1900.

Time Transmission.—*Electrical Time Service.* By F. Hope Jones (conclusion). Detailed description of the gradual development of apparatus for electrical time-transmission. (Ill.) 6¼ cols.—*Mech. Engr.*, Jan. 20th, 1900.

Transformers.—*British Thomson-Houston Transformers.* Description of the standard types of transformers, manufactured by the above-mentioned company, which are distinguished by a number of interesting details. (Ill.). ½ col.—*Elec. Engr.* Jan. 26th, 1900.

4. Telegraphy and Telephony.

Cables.—*An American Pacific Cable.* By Capt. George Owen Squier, U.S.V., U.S. Signal Service. Abstract of a paper read before the American Inst. of Elec. Engrs. on Dec. 27th, 1899. By the construction of such a cable all Pacific cable expenditure, of which fully 90 per cent. goes to foreign corporations at present, would remain in the U.S. 2¾ cols.—*Elec. Wrld. and Engr.*, Jan 6th, 1900.

—— *An American Pacific Cable* (continuation). Abstract of a paper on the subject read at the meeting of the Am. Inst. of Elect. Engrs., Chicago, Dec. 27th, 1899. 3 cols.—*Electr. Engr.* Jan. 18th, 1900.

—— *The American Pacific Cable.* By George Owen Squier. Abstract of a paper read before the American Institute of Electrical Engineers, New York and Chicago, Dec. 27th 1899 (conclusion). In his concluding remarks the author expresses the opinion that the cable across the Pacific will mark an epoch in the history of the world. As regards the probable traffic there is no direct evidence, but taking 150·00 dollars as the average earning power per nautical mile of the long cables of the world, the project should prove a paying investment. The paper is accompanied by two appendixes. 3¼ cols.—*Elec. Engr.*, Jan. 26th, 1900.

Telegraphy.—*The Telepantograph.* Description of an apparatus invented by M. R. Greville-Williams, by means of which a drawing, letter, photograph, diagram, or any other graphic matter, can be automatically telegraphed to any distance; all that is necessary is to write and draw, or to have photographed the original on a thin metal sheet, and to place it in the transmitter; after this a switch is turned, and the writing or drawing is automatically recorded by the receiver at its destination, on paper, wood, metal, etc. (Ill.) 1¾ col.—*Electricity* (New York), Jan. 17th, 1900.

—— *Telegraph Apparatus.* First of a series of contributions containing a minute description of the various instruments employed in the telegraph systems of to-day. 1½ col.—*Electricity* (London), Jan. 19th, 1900.

Telephones.—*The Energy of Telephone Currents.* Important results might be obtained by strengthening the telephone current. It is not easy to measure the strength of telephone currents, and comparatively little has been published on the subject. The experiments described in the present article were made some time ago by Prof. Blake, and the author, in order to determine under what conditions of battery, induction, coil and adjustment of contacts a transmitter would give the best results, and incidentally to measure approximately the energy represented by the strongest telephone currents they could produce.—*Elec. Rev.* (New York), Jan. 3rd, 1900.

—— *The Kinloch Telephone Exchange of St. Louis, Mo.* By Frederick E. Bausch. Description of the very interesting plant of a telephone exchange in St. Louis, that ranks foremost in point of size among the "Independent" Telephone Companies in the United States. (Ill.) 6¾ cols.—*Elec. Wrld. and Engr.*, Jan. 6th, 1900.

—— *Kinlock Telephone System in St. Louis.* Description of the system of a company organised in the year 1897 for the purpose of constructing an

independent te'ephone exchange in St. Lou's, Mo., U.S.A. (Ill.) 5 cols.—*West. Electrician*, Jan. 6th, 1900.

Telephones.—*The Terminal System and Underground and Aerial Lines of the Kinloch Telephone Company.* By Frank Clark Crosby. Description of the terminal room and its equipment, and of the unique underground system. (Ill.) 7½ cols.—*Elec. Wrld. and Engr.*, Jan. 6th, 1900.

—— *A Central Energy Telephone System and Multiple Switchboard at Parkersburg, W., Va.* Description of one of the multiple switchboards which are one of the greatest developments in independent telephony. (Ill.) 1½ col.—*Elec. Rev.* (New York), Jan. 3rd, 1900.

—— *Some Interesting Faults in Telephone Circuits.* The article deals with faults in telephone circuits caused by storms, electric light or power circuits, faulty construction and ordinary wear and tear. 2½ cols.—*Elec. Rev.*, Jan. 19th, 1900.

5. Miscellaneous.

Annealing Armour Plates.—*Electric Process of Annealing Armour Plates.* Abstract of a paper by C. J. Dougherty, Superintendent of the Electrical Department of the Cramp shipyard, read at the meeting of the Engineers' Club at Philadelphia. The author points out that in the annealing process the armour-plates, which are known as Harveyised plates, are hardened on their surface to a depth of about ⅞ of an inch, the hardness being so great that they cannot be drilled. In order to properly mount them, they must first be locally annealed in the spots where they are to be drilled, and after futile efforts to do this by other means, the electrical method was resorted to, and proved entirely successful. In principle, the apparatus used is like the well-known Thomson Electric Welder. The Harveyised plates are now being superseded by the Krupp plates, which are hardened to a depth of 2 in. instead of only ⅞ in.; but notwithstanding this greater depth, the electric method of annealing is found to answer very well for these also. 1 col. —*Mech. Engr.*, Jan. 20th, 1900.

SHIPBUILDING.

Shipbuilding.—*Shipbuilding and Marine Engineering in 1899* (continuation). The article passes in review the work done in the various ports and shipyards (to be continued). 5 cols.—*Engng.*, Jan. 19th, 1900.

Shipyard Appliances.—*Overhead Cranes, Staging and Riveter-carrying Appliances in the Shipyard.* Abstract of a paper by James Dickie read at a recent meeting of the Society of Naval Architects and Marine Engineers, describing the methods used at the slips in the Union Iron Works, San Francisco, U.S.A. 1½ col.—*Mech. Wrld.*, Jan. 26th, 1900.

Steamers.—*The North German Lloyd and it Double Screw Steamers: Kaiser Wilhelm der Grosse* (continuation). Detailed description of the dimensions and equipment of this magnificent modern steamer. (Ill.) 5 cols.—*Dingler's Polyt. Journ.*, Jan. 20th, 1900.

—— *The Steamer Deutschland.* Description of the latest steamer of the Hamburg Line, constructed entirely of German steel. Its deplacement when fully loaded is 23,200 tons. Its measurement gives nearly 16,200 Reg. Tons, and exceeds that of the "Kaiser Wilhelm der Grosse" by 2,500 tons deplacement, and 2,000 Reg. Tons. The article gives a full account of all its dimensions and its equipment. 6 cols.—*Stahl. u. Eisen.*, Jan. 15th, 1900.

Sailing Vessels.—*The Strength of Spars and Rigging of Sailing Vessels.* No. II. (continuation). The present article deals with masts and stays, and gives a mathematical analysis of the strength needed. 4½ cols.—*Engr.*, Jan. 12th, 1900.

Steam Vessels.—*Coaling Vessels at Sea.* Abstract of a paper by Mr. Spencer Miller presented at the annual meeting of the Am. Soc. of Nav. Archts. and Mar. Engrs. The author discusses Lieutenant R. S. Lowry's paper on the subject, read 1883, the plan suggested by Lieutenant Bell, made public 1887, Lieutenant Tupper's plan, the John A. Walsh plan, Lieutenant Niblack's paper, read 1893, various French experiments, and finally his own. 3½ cols.—*Engr.*, Jan. 19th, 1900.

MECHANICAL ENGINEERING.

1. Boilers, Furnaces, and Fuel.

Boilers.—*On the use of Cold Water for Washing Boilers.* By Edward Grafstrom, Mem. Am. Soc. M. E. The author expresses the opinion that the effect of cold water upon the hot steel plate, under the conditions usually connected with the washing out of boilers, does not affect the properties of the steel. 2 cols.—*Railw. Master Mech.*, Jan. 1900.

—— *The Dundon Sectional Water Tube Boiler.* Description of a boiler with some novel features constructed by P. F. Dundon, San Francisco, Cal., U.S.A. (Ill.) 1½ col.—*Am. Shipbuilder*, Jan. 4th, 1900.

Fuel.—*Powdered Coal for Steam Boilers.* The article deals fully with the problem of using cheap and inferior coals, and the various methods of utilizing powdered coal, of which one or two are pointed out as having been successful, notably the Schwartzkopff system. (Ill.) 2½ cols.—*Iron and Coal Trades Rev.*, Jan. 26th, 1900.

—— *Advantage of Coal Dust Firing.* Summary of a communication, entitled *Chauffage Industriel au Poussier du Charbon*, to the "Société des ingénieurs des Mines du Nainaut," describing successful firing of low grade fuels in Germany. 1 col. *Am. Mfctr.*, Jan. 11th, 1900.

—— *Economy of Fuel in the Chemical Industries.* Progress in apparatus utilizing the principles of multiple evaporation by which a great economy is effected. (Ill.) 2½ cols.

—— *Cheap Fuels.* Abstract of a paper, by R. E. Crompton, before the Institution of Electrical Engineers. The paper deals with the influence of cheap fuels on the cost of electrical energy. 5 cols.—*Engng.*, Jan. 12th, 1900.

Steam Power.—*The Economical Generation of Steam Power.* (Continuation.) By Benj. A. Tapp. Account of a system of four draught, applied in connection with the "Koker" stoker, and of an American self-stoking furnace. (Ill.) 5 cols.—*Electr. Engr.*, Jan. 19th, 1900.

Stoker.—*The "Koker" Stoker.* Description of an automatic stoker, constructed by Messrs. Meldrum, Bros., of Manchester, after the specifications of Meldrum's and Clayton's patents. (Ill.) 1½ col.—*Chem. Trade Journ.*, Jan. 20th, 1900.

Superheated Steam.—*History of Superheated Steam.* By J. H. Ashley, London. The author points out that its vital economy was recognised in 1828, then abandoned, and is taken up again to-day, and mentions the pioneers that voted its adoption. 2 cols.—*Am. Mfctr.*, Jan. 11th, 1900.

2. Compressed Air.

Compressed Air.—*A Small Motor-Driven Air Compressor.* Account of an air compressor orginally designed for service in connection with air-brakes on electric cars, but rendered valuable for use in many other situations by its simplicity and efficiency. (Ill.) 2 cols.—*Engng. News*, Dec. 21st, 1899.

—— *A Neat Design of Motor-Driven Air Compressor.* The article fully describes an air compressor, constructed by the Standard Air-Brake Co., of New York. (Ill.) 2 cols.—*Mech. Engr.*, Jan. 27th, 1900.

Liquefaction Experiments.—*The Liquefaction of Air.* Abstract of a paper by Arthur L. Rice, Junr., presented at the New York meeting of the Am. Soc. of Mech. Engrs. Very full account of the methods employed for the purpose. (Ill.) 4 cols. —*Engng. News*, Dec. 21st, 1899.

Liquefaction.—*Compression and Liquefaction of Gases.* Abstract of a paper by Arthur L. Rice, Junr., presented at the New York meeting (Dec., 1899) of the American Society of Mechanical Engineers. (Ill.) 3¾ cols.—*Mech. Engr.*, Jan. 27th, 1900.

Ventilation.—*Ventilation without Draughts.* By Arthur Rigg, C.E. Description of practical systems of ventilation in all sorts of buildings. 20 cols.—*Journ. Soc. of Arts*, Jan. 19th, 1900.

3. Engines and Motors.

Accumulators.—*Accumulator Trials.* Account of the preliminary report of the committee appointed to conduct the tests of electrical accumulators for the Automobile Club of France. 2½ cols. —*Electr. Engr.*, Jan. 19th, 1900.

—— *Oil Engines and Motor Cars.* By Anthony G. New. This author deals in his new series of articles with the application of oil engines to motor car, under the headings of (1) the car, (2) the engine. (3) interactions of car and engine, (4) present-day vehicles, (5) requirements and possibilities. 4 cols.—*Engr.*, Jan. 5th, 1900.

Automobiles.—*Oil Engines and Motor Cars.* By Anthony G. New. Conclusion of a discussion on modern motor cars and the use of oil engines. 4 cols.—*Engr.*, Jan. 12th, 1900.

—— *Electricity on the Common Roads.* Abstract of a paper by Mr. Thomas Parker, of Wolverhampton, read after the Automobile Club's house dinner on the 10th inst., in which the author gives a short sketch of the history of electricity on common roads of this country. 2½ cols.—*Elec. Engr.*, Jan. 26th, 1900.

—— *English Electrical Vehicles.* Short account of a four-wheel dog-cart recently brought out by the Electric Motive Power Company, Ltd., 74, Caistor Road, Balham, and also a four-wheel phaeton by the same company. (Ill.) 1 col.—*Industries and Iron*, Jan. 26th, 1900.

—— *The Blaxton Steam Generator.* Account of a generator of the "flashing" type, and consisting of a number of coils of steel tubing, 1 inch internal diameter, each coil forming a separate element and having about 10 square feet heating surface. The generator is fired by liquid fuel, and its principal feature is the means employed for automatically adjusting the consumption of fuel in the same ratio as the consumption of steam. (Ill.) ¾ col.—*Automotor Journ.*, Jan. 1900.

—— *An Automobilette.* Description of a light vehicle constructed by Mr. Frank F. Wellington, of St. George's Square, Regent's Park, London, which, in addition to other qualities, offers the comfort and accessibility of the pony chaise, and can be handled by elderly as well as by young people. (Ill.) ¾ col.—*Automotor Journ.*, Jan. 1900.

—— *The Hurtu Electric Carriage.* The article is based on a contribution of A. Delaselle in *La Locomotion Automobile*, and describes an electric carriage, built under the patents of Messrs. A. de Mackenna and Gigot by the "Compagnie des Automobiles et Cycles Hurtu," which is front-driving and steering and has a general resemblance to a Krieger carriage, but entirely differs in details. (Ill.) 1½ col.—*Automotor Journ.*, Jan. 1900.

—— *The Oppermann System of Electromobiles.* Description of vehicles constructed by Mr. Carl Oppermann, of Wynyatt Street, Clerkenwell, London. In his latest design the framing consists of weldless steel tubing, and to this is attached the whole of the motor mechanism, springs, etc. (Ill.) ¾ col.—*Automotor Journ.*, Jan. 1900.

Automobiles.—*The Liverpool Trials of Motor Vehicles.* Abstract of the elaborate report of the judges who conducted the trials of the motor vehicles at Liverpool, from July 31st to August 2nd, 1899. A very long section of the report is devoted to a description, accompanied by illustrations of the various vehicles, from which the abstract freely quotes. (Ill.) 8 cols.—*Automotor Journ.*, Jan. 1900.

—— *Motor Vehicles.* Abstract of a paper by Mr. Alex. Craig, M.C.E.I., read before the Cycle Engineers' Institute, Coventry, Dec. 14th, 1899, dealing with the question on broad lines. 4 cols.—*Automotor Journ.*, Jan. 1900.

—— *Heavy Motor Wagons for Liverpool Traffic.* Abstract of a paper by Mr. Arthur Musker, Assoc. M. Inst. C.E., before the Liverpool Engineering Society, Dec. 13th, 1899. The paper deals with the question of heavy motor wagons as applied to Liverpool traffic, but it will apply to similar traffic elsewhere. (Ill.) 5 cols.—*Automotor Journ.*, Jan. 1900.

—— *Improvements in Internal Combustion Motors.* The article deals with recent improvements introduced in motor-construction by Messrs. Crossley and Atkinson, Manchester. (Ill.) 1½ col. —*Automotor Journ.*, Jan. 1900.

—— *A Reversible Gas Motor.* Description of a reversible gas motor, which has been invented by Messrs. Macdonald and Mackenzie. The author remarks that if the principles of this motor, the advantages of which are obvious, can be applied to oil-motors, the utility for automobile purposes would be greatly enhanced. (Ill.) 1 col.—*Automotor Journ.*, Jan. 1900.

—— *The Manufacture of Electric Automobiles.* The article describes the methods of manufacture employed by the Columbia and Electric Vehicle Company, of Hartford, Conn., U.S.A. (Ill.) 5½ cols.—*Elec. Wrld. and Engr.*, Jan. 13th, 1900.

—— *The Usual Automotor Systems.* By Prof. H. Bachner, of Stuttgart. Description of the more common systems of automotors and their advantages and defects. (To be continued.) (Ill.) 7½ cols.—*Dingler's Polyt. Journ.*, Jan. 20th, 1900.

Engines.—*Blowing Engines for the National Steel Company.* Description of three interesting blowing engines, recently installed at the Ohio Works of the National Steel Company by Wm. Tod & Company, of Youngstown, Ohio, U.S.A. (Ill.) 1½ col.—*Power*, Jan. 1900.

—— *Receiver Drops in Multiple Expansion Engines.* Abstract of a paper read by Prof. R. L. Weighton, M.A., read before the North-east Coast Inst. of Engrs. and Shipbuilders, giving and explaining the results obtained from certain trials recently completed, on the experimental engines at the College of Science, Newcastle-upon-Tyne. 7 cols.—*Mech. Engr.*, Jan. 27th, 1900.

—— 2,000 *I.H.P. Compound Mill Engine.* Description of a representative class of compound engines that are coming more and more into favour with mill-owners, and others requiring large power, The engines described were built in 1896 by Hick, Hargreaves and Co., Ltd., Bolton. (Ill.) 2½ cols.—*Engr.*, Jan. 12th, 1900.

—— *The Erection of Engines and Shafting—XXVII.* The present article deals with friction and lubrication and discusses the more common methods. (To be continued.) 2½ cols.—*Mech. Wrld.*, Jan. 26th, 1900.

Indicator.—*Ripper's Patent Mean-Pressure Indicator.* Describes Prof. Ripper's invention which, in a simplified form, is now being put on the market by Messrs. Schäffer and Budenberg, Manchester. (Ill.) 1½ col.

Oil Engine.—*Oil Engine with Direct-Connected Generator.* Description of kerosene engines, constructed by Mietz and Weiss, New York, which are made in eight sizes ranging from 1 to 20 horse-power. The one horse-power engine weighs 600

pounds and covers from 30 × 36 inches floor space, while the 20 horse-power engine requires 60 × 90 inches and weighs 6,500 pounds. The illustration accompanying the text represents a 4 horse-power engine, direct-connected to a generator, being mounted on a common base and furnishing power for 40 16-candle-power lamps. (Ill.) ⅝ col.—*Sci. Am.*, Jan. 13th, 1900.

Steam Engines.—*The Fly Ball Governor.* By H. H. Kelley. Description of the use of the fly-ball governor and the most advantageous conditions for its effective working. 3 cols.—*Engr.* (Cleveland), Jan. 18t, 1900.

Steam Wagons.—*The Simpson-Bodman Steam Lorry.* Account of a steam lorry, constructed by Messrs. Simpson and Bodman, of the Pomona Engine Works, Cornbrook, Manchester, which, the builders say, is the result of nearly four years' continuous experiment. (Ill.) 4 cols. *Industries and Iron*, Jan. 19th, 1900.

Valve-Gear.—*The Long Radial Valve-Gear.* Description of a radial valve-gear, with some novel features that may be applied to any reversible or non-reversible engine of ordinary type. (Ill.) 2½ cols. *Engr.* (Cleveland).

Valves.—*Pressure-Reducing Valves.* Abstract of an article published in the *Zeitschrift des Vereins Deutscher Ingenieure* describing various systems of pressure-reducing valves, and their employment. (Ill.) 3½ cols. *Mech. Wrld.*, Jan. 26th, 1900.

4. Power and Transmission.

Belt Conveyor.—*A Belt Conveyor for Foundation Work.* A 120,000 horse-power house has been begun for the New York Gas, Electric Light, Heat and Power Company, near the East River. There are about 25,000 yards of earth and 9,000 yards of rock to excavate, and a novel plant has been installed to remove the material to scows, which are towed to sea. A trench about 7 ft. wide at the bottom was dug near the long axis of the lot, and in this trench has been placed a belt conveyor, which delivers the spoil to the scows. This conveyor is described in the article. (Ill.) 1½ col. *Engng. Rcd.*, Jan. 13th, 1900.

Fly-Wheels.—*Fly-Wheel Design.* By A. J. Frith. The author refers to the fact that at a meeting of the American Society of Mechanical Engineers a member presented it with a drawing of a band fly-wheel, which had a rim of cast-iron with shallow cross-ribs, meeting in a pad on the under side, to which the arms were bolted. This wheel had accidentally been run up to an unusual speed, and was afterwards found to be out of truth. Upon examination it was discovered that about 50 per cent. of the intersections of the arm, pads and ribs on the rim were cracked around the entire wheel. It was suggested that perhaps the effect of the arms of a fly-wheel on its rim, when effected by centrifugal force, had not been sufficiently considered by designers, and that something more might have to be considered in the designs of fly-wheels than is ordinarily laid down in our text books regarding the mutual proportions of arms and rim. The author in the present article gives a short account of what seems to have been the cause of the accident, and suggests a possible remedy. (Ill.) 2¾ cols. *Mech. Engr.*, Jan. 20th, 1900.

Steam Turbines.—*A Triple-Expansion Steam Turbine.* Account of a steam turbine, designed by James H. K. McCullum, Toronto, Canada. ½ col. *Engr.* (Cleveland), Jan. 18t, 1900.

Windmills.—*Home-made Windmills in Nebraska.* Comment on a series of articles in the *Scientific American, Supplement*, beginning with the issue of Jan. 13th, describing windmills invented and constructed by farmers in Nebraska. By their genius they have been able to irrigate many acres of garden truck, fruit land, and even farm land, at a trifling expense. Stock is supplied with water, ranchmen and shepherders are benefited, etc., and the comfort of the village and the rural home is often enhanced. The illustrations certainly indicate surprising cleverness on the part of the builders, and the expense of their mills, not including labour, is said not to exceed five dollars in the average. (Ill.) 1½ col. *Sci. Am.*, Jan. 13th, 1900.

5. Machine Works, Shop and Foundry.

Drilling Machine.—*Radial Drilling Machine.* The article describes a radial drill of American origin, constructed by the Fosdick and Holloway Machine Tool Company, Cincinnati. (Ill.) 1½ col.—*Engr.*, Jan. 12th, 1900.

Lubricator.—*Automatic Lubricator.* Description of an ingenious lubricator for shafting, intended for the supply of solid lubricants, put in the market by the Aktiebolaget Lubricator, of Garfvaregatantz, Stockholm. (Ill.) ½ col.—*Engng.*, Jan. 12th, 1900.

Machine-Tools.—*Shaping Machine.* Description of a double-headed shaping machine, constructed by Loudon, Brothers, of Glasgow, for the Creusot Works. (Ill.) ½ col.—*Engr.*, Jan. 9th, 1900.

Steam Power.—*The Economical Generation of Steam Power.* By Benjamin A. Tapp (continuation). In the present instalment the author deals with modern apparatus for promoting economy, which makes great strides on the Continent, notably Germany, though neglected in England, and describes the Schmidt system of super-heating, the Schworer superhenter, etc. (Ill.) 4½ cols.—*The Engr.*, Jan. 25th, 1900.

6. Miscellaneous.

Circular Saws.—*Improved Circular Saw Guard.* Short account of a guard manufactured by Messrs. Malkin, Binns, and Foster, Gaol Lane, Halifax, which, it is said, is already largely in use. ½ col.—*Mech. Wrld.*, Jan. 26th, 1900.

MINING AND METALLURGY.

1. Coal and Coke.

Coalfields.—*The Northumberland Coalfield.* IX. Description of Walker Colliery contained in an area of about 1,250 acres, in which mining operations have been carried on for nearly a century and a half. (Ill.) 1¾ col.—*Coll. Guard.*, Jan. 26th, 1900.

Coal Mining.—*Winding Drum with Tangential Arms at the Blanzy Colliery.* Description of a new kind of winding drum with tangential arms in tension, manufactured at the workshops of the Blanzy Colliery for the Saint Amédée shaft of the Montmaillot division, Saône et Loire, France. The idea of this new kind of drum was suggested by a bicycle-wheel, and was first put into practice in 1897, but has since been improved upon by making the drum lighter. (Ill.) 2½ cols.—*Coll. Guard.*, Jan. 26th, 1900.

—— *The Ocean Coal Company's Deep Navigation Pits at Treharris.* Description of the collieries which were sunk in 1879 to the Aberdare 4-feet seam, and are situated in Glamorganshire. (Ill.) 5 cols.—*Ir. and Coal Trades Rev.*, Jan. 19th, 1900.

—— *Sinking through Heavily Watered Strata.* Abstract of a paper by Richard Robinson, read before the British Society of Mining Students. Article giving a good summary of the method. (Ill.) 1¼ col.—*Ir. and Coal Trades Rev.*, Jan. 19th, 1900.

—— *The Ignition of Firedamp and Coal Dust by means of Electricity.* By Sidney F. Walker (conclusion). Full description of very interesting experiments. 3 cols.—*Coll. Guard.*, Jan. 19th, 1900.

—— *Arrangements for Preventing Shaft Accidents.* Account of a few objections to M. Léon Thiriart's

suggestions of devices for preventing accidents in shafts, and of M. Thiriart's answers published in the *Annales des Mines de Belgique.* 2 cols.—*Coll. Guard.*, Jan. 19th, 1900.

Friction Clutches.—*Some Types of Friction Clutches.* The author points out that friction clutches are largely used in colliery work. In haulage, when the ropes have frequently to be started or stopped, it is important, having regard to the life of the ropes, that they should be started or stopped with as few jerks and strains as possible. To overcome the disadvantages of sudden jerks friction clutches are used, of which the author describes a great many types. (Ill.) 7 cols.—*Ir. and Coal Trades Rev.*, Jan. 12th, 1900.

Pit Props.—*Safety Pit Props.* Patent gear invented by Mr. Sebastian Smith, of Shipley, which prevented a serious accident some six months ago in the Shipley Collieries, Derbyshire. (Ill.) ½ col.—*Engr.*, Jan. 12th, 1900.

2. Copper.

3. Gold, Silver, and Diamonds.

Gold Mining.—*Mining at Leadville in* 1899. Account of the production, estimating the output of the mining camp during last year at about $10,000,000, and giving the output of the camp in all metals for the past twenty-one years as totalling $262,000,000. 1 col.—*Engng. & Min. Journ.*, Jan. 6th, 1900.

—— *Leadville, Colorado, Mines in* 1899. Comments on the causes of the unpleasant features shown by the statistics, and forecast of more hopeful prospects. 1¾ col.—*Engng. & Min. Journ.*, Jan. 13th, 1900.

—— *Gold and Silver in* 1899. Estimate of the gold production of the world during last year, compiled from official sources and private information. 2 cols.—*Engng. & Min. Journ.*, Jan. 6th, 1900.

—— *Cripple Creek, Colorado, Mines in* 1899. Comments on the mining progress in that district during last year, and forecast of a good outlook for the present. 1½ col.—*Engng. & Min. Journ.*, Jan. 13th, 1900.

—— *The Cyanide Plant of the Rose Gold Mining Co. at Victor, California.* Description of a mill, which is as nearly automatic as possible, and permits to treat with profit a grade of ore, hitherto considered outside the pale of cyanide operations. ¾ col.—*Engng. & Min. Journ.*, Jan. 13th, 1900.

4. Iron and Steel.

Iron and Steel.—*The Metallurgy of Iron and Steel.* By Prof. A. Humboldt Sexton. (Continued.) The present article deals with the foundry, pig-iron for foundry use, effect of remelting, the cupola, its working and its size, fuel consumption, air supply, centreblast cupolas, patterns, moulding, green sand and dry sand, loam moulding, drill casting, malleable cast-iron, forms of casting, etc. (Ill.) 5¾ cols.—*Mech. Engr.*, Jan. 20th, 1900.

—— *Iron and Steel.* Account of the iron industry in the United States during last year, which the author states to have been distinguished by unparalleled prosperity. 3 cols.—*Engng. and Min. Journ.*, Jan. 6th, 1900.

Iron Industry.—*Foundry Iron.* Abstract of a paper read before the South Staffordshire Iron and Steel Institute, by Herbert Pillkington, M.Inst. C.E. The author points out that foundry iron in Great Britain has for some obscure reasons never been the subject of much exact or scientific investigation. A recent visit to America, he declares, convinced him that not only are Americans very much in advance of us in the production of steel irons and steel, but that they also are very much in advance of us in the production of foundry iron and foundry practice. He thinks that foundry iron ought to receive as much investigation—both chemical and physical—as that which is now bestowed upon steel. Producers of foundry iron he concludes, have not sufficient knowledge of the precise chemical constituents of their iron to sell by analysis, nor have they sufficient knowledge to buy by analysis; nor do they know sufficient about the behaviour of iron of a given analysis to answer for its conduct. 2½ cols.—*Iron and Coal Trades Rev.*, Jan. 26th, 1900.

Iron Mines.—*Lake Superior Iron Mines in* 1899. Account of the astonishing increase of the Lake Superior iron ore shipments, and the ease with which the output was accomplished. 2 cols.—*Engng. and Min. Journ.*, Jan. 13th, 1900.

Iron Ores.—*Greatest Lake Iron Ore Output.* By Horace J. Stevens. The article consists of a review of the tonnage during the last and past years, yielded by the Lake Superior Iron Ore Field, and estimates of future outputs. 3½ cols.—*Am. Manftr.*, Jan. 4th, 1900.

Iron Works.—*Central Condensing Plants for Iron Works.* Description of a condensor which provides for a very thorough and effective breaking up of steam through the tubes, and transmission of heat from steam to water. 4 cols.—*Am. Manftr.*, Jan. 4th, 1900.

—— *Central Condensing Plants for Iron Works.* Description of a typical accumulator surface condensing plant erected by Messrs. Klein, of Frankenthal at Zollern Colliery, Westphalia. (Continued.) 1 col.—*Am. Manftr.*, Jan. 11th, 1900.

—— *Modern Iron Founding.*—III. By C. W. B. The article contains practical instructions and suggestions, and describes the most approved methods. (Ill.) 1¾ col.—*Mech. World*, Jan. 26th, 1900.

Steel Industry.—*The Heat Treatment and Microstructure of Steel.* Abstract of paper by A. Campion, A.I.C., F.C.S., read before the West of Scotland Iron and Steel Institute. The author points out that the subject, though of vital importance, has been much neglected for many years. Within the last few years the question has been again taken up, more especially by Mr. A. Sauveur, but with all his elaborate apparatus this investigator did little more than confirm the results obtained by Brinnel. (To be continued.) 4½ cols.—*Industries and Iron*, Jan. 26th, 1900.

Steel Works.—*The Manufacture of Iron and Steel in India.* Abstract of a Report of the Indian Government, by Major R. H. Mahon, R.A. The Report endeavours to collect the available information bearing upon the subject of the capability of India as a steel manufacturing country. (To be continued.) 5¼ cols.—*Coll. Guard.*, Jan. 19th, 1900

5. Mining.

Mining.—*Progress of Mining in Montana in* 1897. Summary account of the production, which showed that Montana shared the general prosperity of the year, and that the industry, with a few exceptions, did not suffer from strikes, shut-downs, disasters, &c. 1 col.—*Engng. & Min. Journ.*, Jan. 6th, 1900.

—— *The Metal and Mineral Output of the United States* in 1899. The article contains as a preliminary statement, a summary of the production of the more important metals and minerals in the United States for 1899. 4 cols.—*Engng. and Min. Journ.*, Jan. 6th, 1900.

—— *Mechanical Ore Unloader.* By Waldon Fawcett. Description of the mechanical device of which the first type has recently been installed on the docks of the Carnegie Steel Company, at Conneant, O., U.S.A., regarding which Carnegie has announced his intention of making it the greatest ore unloading port of the world. (Ill.) 2 cols.—*Sci. Am.*, Jan. 6th, 1900.

—— *Blasting with High Explosives.* By Harold Bonner. The author deals very fully with the whole subject, from its legal as well as mechanical

aspects, and discusses the various methods and explosives. (Ill.) 4 cols.—*Ir. and Coal Trades Rev.*, Jan. 26th, 1900.

Mining.—*Manganese Mining in Brazil.* Account of a new mine of manganese, lately opened in the State of Bahia. ½ col.—*Mech. Engr.*, Jan. 6th, 1900.

6. Miscellaneous.

Nickel Steel.—*Nickel Steel, Its value as an Alloy.* By David H. Brown. Synopsis of experiment and opinions given at the American Institute of Mining Engineers. (To be continued.) 2 cols.—*Am. Mfctr.*, Jan. 11th, 1900.

MUNICIPAL ENGINEERING.

1. Gas Supply.

Acetylene. — *Explosive Side of Acetylene.* By Frederick H. M'Gahie. Description of various devices for the purpose of reducing the danger of explosion in the use of acetylene. 2 cols.—*Sci. Am.*, Jan. 6th, 1900.

—— *Acetylene Gas and its Development.* Review of the recent development of the manufacture and uses of acetylene gas. (To be continued.) 2 cols.—*Electro. Chem. Rev.*

—— *The Second International Acetylene Exhibition in Budapest* (1899). Abstract of the report by Karl Neudeck, Engineer, outline of the exhibition in general and detailed description of the most striking exhibits. (To be continued.) 11 cols.—*Ztschrft. d. Oest. Ing. u. Archit. Ver.*, Jan. 12th, 1900.

—— *The Second International Acetylene Exhibition at Budapest.* By Karl Neudeck, delegate of the "Oest. Ing. u. Archit. Ver." (continued.) Description of exhibits. (Ill.) 7½ cols.—*Ztschrft. d. Oes . Ing. und Archit. Ver.*, Jan. 19th, 1900.

—— *The Second International Acetylene Exhibition at Budapest* (1899). (Conclusion). The article deals with the chief exhibits of which it gives full description. 5 cols.—*Ztschrft. d. Oest. Ing. und Archit. Ver.*, Jan. 26th, 1900.

Gas Lighting.—*Apparatus for the Analysis of Illuminating and Fuel Gases.* By Mr. George E. Thomas. Reproduction of an article published in the *Journal of the American Chemical Society.* The author points out that much danger and loss is incurred in some methods used for the purpose, incident to the reputed connecting and disconnecting of apparatus, while the size of others renders them inapplicable for transportation. With these objectionable features in mind, he adds, he decided upon constructing an apparatus compact and efficient for technical work, which he describes in the present article. (Ill.) 2 cols.—*Gas Wrld.*, Jan. 27th, 1900.

—— *The Proposed Gas Exhibition and Congress of Gas Engineers at the Paris Exhibition.* Article mentions that there will be a Congress of Engineers and others interested in the progress of the gas industry, at the Paris Exhibition, on Sept. 3rd, 4th and 5th. In connection with the Exhibition, it is intended to have a representative collection of gas appliances in a building specially erected for the purpose. The article is accompanied by illustrations, showing this building in elevation and three cross-sections. 1½ col.—*Journ. of Gas Lghtng.*, Jan. 16th, 1900.

—— *The Recovery of Nitrogen in Coal Distillation.* Abstract from a paper read before the Scottish section of the Society of Chemical Industry, by W. Carrick Anderson, D.Sc., and James Roberts, F.C.S., dealing with the way in which the nitrogen of coal distributes itself on heating, and the conditions under which ammonia is obtained in retorts and ovens, and also with the limits of ammonia production and the obstacles in the way of reaching these limits. 8¾ cols.—*Gas Wrld.*, Jan. 20th, 1900.

2. Sewerage.

Sewerage.—*Sewage Disposal at Alliance, O.* Description of a sewage plant located on the bank of the Mahoning River, near Alliance, Ohio, U.S.A., in which the system of chemical precipitation is employed. 2¾ cols.—*Engng. Recd.*, Jan. 13th, 1900.

—— *Improved Methods for the Purification of Sewage and Water, as shown in the Operation of the Municipal Plant at Reading, Pa.* Abstract of a paper read before the Franklin Institute by John Jerome Deery. (Ill.) 10 cols.—*Contract Journal*, Jan. 17th, 1900.

—— *The Sewerage of Edinburgh, Scotland.* By James H. Fuertes. Description of the sewage system and its working. (Ill.) 2 cols.—*Engng. Recd.*, Jan. 23th, 1900.

3. Streets and Pavements.

Pavements.—*Failures in Asphalt Pavements.* An article in the annual report of Captain Lansing H. Beach, Engineer Commissioner of the District of Columbia, written by Mr. A. W. Dow, Inspector of Asphalts and Cements, and treating on failures in asphalt pavements. This article is of importance on account of the author's unusual opportunities for studying the subject, and deals with disintegration by cracking in long irregular cracks, disintegration from rolling or crowding, and disintegration of pavements in spots. 6 cols.—*Engng. Recd.*, Jan. 6th, 1900.

4. Water Supply.

Waterworks.—*The Second Waterworks of the Vienna Mountain-source Establishment, in District X. (Favoriten).* Full description of buildings and equipment, by Fr. Borkowitz, Building Inspector of the Municipal Building Department. (Ill.) 5½ cols.—*Ztschrft. d. Oest. Ing. und Archit. Ver.*, Jan. 26th, 1900.

—— *The Water Purification Plant at Albany, N.Y.* Description of the largest water purification plant in the United States. At its normal rate the plant is 16,800,000 gallons per day, when all the eight beds are in service; and 14,700,000 gallons when one is out of use for cleaning. 5½ cols.—*Engng. News*, Jan. 11th, 1900.

NAVAL & MILITARY ENGINEERING.

Coast Defence Guns.—*Messrs. Schneider & Co.'s Works at Creusot. No. LXXV.* The article is one of a very long series in describing the plant and output of this famous establishment. (Ill.) 3½ cols.—*Engng.*, Jan. 12th, 1900.

—— *Messrs. Schneider & Co.'s Works at Creusot. No. LXXVI.* Description of a 12-inch coast defence gun and its mounting, which is fitted in an elevator and disappears in a pit for loading the gun. (Ill.) ⅝ col.—*Engng.*, Jan. 19th, 1900.

Cruisers.—*The United States Protected Cruisers "Denver" Class.* Full description, accompanied by a two-page plate of the new Denver class of protected cruisers. ½ col.—*Engng.*, Jan. 12th, 1900.

Gun Mountings.—*Elswick Naval Mountings, No. 1.* The article deals with the mountings described in Sir Andrew Noble's paper, read before the Institution of Naval Architects last year. (Ill.) 1 col.—*Engr.*, Jan. 19th, 1900.

Japanese Vessels.—*The New Japanese Destroyers.* Description of the group of six vessels, which, as the successful termination of the trials of the destroyer, *Niji*, proves, are certainly remarkable even in these days of high-speed craft. 1½ col.—*Engng.*, Jan. 12th, 1900.

Protective Shields. — *Devices for Attacking Trenches.* General account of trenches and their uses, and description of a portable shield invented by Captain Boynton, of Camwell & Co. 1¼ col.—*Engr.*, Jan. 12th, 1900.

REVIEWS OF BOOKS . . .

Central Station Electricity Supply. By Albert Gay, M. Inst. E. E., and C. H. Yeaman, A. Inst. E. E. Whittaker & Co., London, 1899.

What distinguishes this book from so many others written nowadays on the applications of electricity is that the authors are men who have a thorough working knowledge of the subjects with which they deal, and not merely a theoretical or laboratory knowledge. Unfortunately it is not often the case that practical workers possess the necessary literary talent to communicate their knowledge, but if good writing consists in the clear and lucid expression of well-conceived ideas, Messrs. Gay and Yeaman can certainly claim to have produced a well-written book on a very interesting subject. If any fault might be found with the volume under consideration it would be that, although formulas and mathematical considerations are omitted, it appeals exclusively to readers who have a practical knowledge of electricity, while, with the addition of a few chapters on electricity and magnetism in general, summarising the elementary physical laws coming into play in the distribution of the electrical current for lighting and motor purposes, it would find a much larger class of readers, and it is certainly desirable that the general public should obtain some knowledge of the problems and difficulties placed before the undertakers of electrical supply so as to be able to judge more fairly where their expectations are disappointed. At all events, it would be well if the lay critics of modern electrical engineering were to glance, at least, at the second chapter of this interesting book, which contains pointed extracts from legislative Acts and municipal regulations, showing how serious a drawback some of these offer to the development of electrical enterprise, and what injustice has been done to some of the companies who were pioneers in the field. There can be no doubt that there was much that was unsound, and even dishonest, in early electric enterprise, but, nevertheless, the Electric Lighting Act, 1882, for instance, containing absolutely impossible demands, was certainly a serious blunder, and the direct cause of the breakdown of some of the companies that might otherwise have obtained legitimate success.

The perusal of the volume before us, which very wisely is confined to the subject of its title, *i.e.*, Central Station Electricity Supply, that in itself covers so large a field as to require perhaps a much more compendious treatment, renders it very clear to the reader that, even yet, although remarkable progress has been made in the application of electricity for light and motor purposes, the subject, to a great extent, is still in its experimental stage of comprehension. The chapters on "direct systems of supply" and "converted systems of supply," together with that on "electrical equipment," which deal very fully and yet concisely with the methods of distribution and the various generators in the market, though perhaps with the latter not quite fully enough, bring out the fact, so embarrassing to the practical electrician, that, although the number of systems and the varieties of apparatus are legion, scarcely any one of them represents fully-elaborated ideas, or is characterized by features that render it definitely superior as compared with any other. There have been, of course, numberless abortive inventions to which we naturally do not allude here; but, among those that hold their own by their intrinsic merits, there are still so many which are nearly equal in efficiency, as far as they are understood, that a choice between them is rendered very difficult, and must be left to hazard, though perhaps local peculiarities give here and there an indication, which of the many it would be best to "try." In reality, therefore, electrical distribution is as yet in the state of trial, and it is natural enough that blunders are made on many occasions; but the public, instead of blaming so severely the undertakers whenever an installation does not strictly fulfil its promises, might show some indulgence with those who have to face difficulties that are more rarely to be met with in older industries.

Messrs. Gay and Yeaman very fully discuss these difficulties without, it is true, in many cases offering a solution, but the fact is that time and experience alone can give this solution, and many yet will be the failures by which such experience has to be bought ere everything will work as smoothly as it generally does at present in the manufacture of gas, or in the utilisation of steam. That electrical applications have found so ready a welcome among the public in general, notwithstanding the fact that some of them are still in their elementary stage, is due mainly to their general attractiveness, their cleanliness and the convenience of their use, which seems to compensate most consumers for the slightly increased expenditure for and the occasional breakdown of electric apparatus. Books such as the one under review will considerably contribute to further progress, since they place clearly before the electrical engineer and those who desire to undertake the installation of supply works the difficulties that will have to be faced and the precautions that have to be taken, stated by men who no doubt, like others, have had to pay more than once by mistakes for the experience that they place at the disposition of their readers.

It is true that man is rarely inclined to learn from the experience of others, and that there is a strong temptation to try new and unexplored paths, still, those who are wise will do well to obtain a thorough idea beforehand of what they may have to expect in their new enterprise, and to study at least its possibilities. For such a study, as far as the installation of an electrical supply station is concerned, the volume of Messrs. Gay and Yeaman offers a very practical compendium that can be thoroughly recommended.

Messrs. Whittaker & Co. will publish immediately a new edition of J. Bowen Cooke's well-known work ***British Locomotives; their History, Construction and Modern Development.*** It has been thoroughly revised and brought up to date, and is fully illustrated with the latest type of locomotives.